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SHIP MOTION TRADE-OFF ANALYSIS FOR THE CONTAINER OFFLOADING AND TRANSFER SYSTEM (COTS)

D. C. SUMMEY
T. C. WATSON

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ADMINISTRATIVE INFORMATION

This report was prepared in support of the Container Offloading and Transfer System (COTS) for NAVSEA 032 under Task Area SF 53 531 202. NAVSEA 032 Project Manager is Larry Benen. The principal development activity for COTS is the Naval Facilities Engineering Command, Code 031A, under the direction of Milon Essoglon. The work was carried out under the general direction of Naval Coastal Systems Center (NCSC) Task Leader Roddie Bailey. This report presents theoretical absolute motion data for containerships and lighter vessels as well as relative motions between the two crafts for several sea states of interest. The predicted motion data are representative of those likely to be encountered in full-scale sea trials and therefore considered useful in COTS design trade-off analysis.

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Ship motion Response Amplitude Operators (RAOs) were predicted for three containerships and three lighter vessels. Ship motions (surge, heave, sway, pitch, roll, and yaw) were also computed for three sea spectra: a Pierson-Moskowitz, a Bretschneider, and a Bretschneider plus swell. Ship and crane motion data for head, quartering, and beam wave incidence angles are presented in tabular form with plots comparing barge motion RAOs given as a function of wave incidence angles. Significant displacements, velocities, and accelerations were

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20. ABSTRACT (continued):

calculated in each of the three coordinate directions for various rigid boom crane configurations. A sample procedure is presented for using the large volume of motion data available for the Container Offloading and Transfer System (COTS) system design.

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FOREWORD

Department of Defense (DoD) planning for the logistics support to sustain major contingency operations, including amphibious assault operations and Logistic-Over-the-Shore (LOTS) evolutions, relies extensively on the use of United States Flag commercial shipping. Since the mid-1960s, commercial shipping has been steadily shifting towards containerships, Roll-On/Roll-Off (RO-RO) ships, and barge ships; e. g., LASH and SEABEE. By 1985, as much as 85 percent of United States Flag sea-lift capacity may be in container-capable ships--primarily non-self-sustaining (NSS) containerships. Though amphibious assault and LOTS operations are usually conducted over undeveloped beaches, such ships cannot operate without extensive port facilities. Expeditious response times preclude conventional port development, posing a serious problem for containers handled in this environment. This problem, as addressed in the overall DoD Over-the-Shore Discharge of Cargo (OSDOC) efforts involving development by the Army, Navy, and Marine Corps, is documented in the "DoD Project Master Plan for Surface Container Supported Distribution System" and the OASD I&L system definition paper "Over-the-Shore Discharge of Cargo (OSDOC) System."

In response to the DoD Master Plan, Navy Operational Requirement OR-YSL03 has been prepared for an integrated Container Offloading and Transfer System (COTS) for discharging container-capable ships in the absence of port facilities. The COTS Navy Development Concept (NDCP) No. YSL03 was promulgated in July 1975 and the Naval Material Command tasked with the development. The Naval Facilities Engineering Command has been assigned as Principal Development Activity (PDA) with assistance from the Naval Sea Systems Command.

Included in the COTS advanced development program are the ship unloading subsystem, the ship-to-shore subsystem, and common system elements. The ship unloading subsystem includes: (1) the development of Temporary Container Discharge Facilities (TCDF) using merchant ships and barges with add-on cranes and support equipment to offload non-self-sustaining (NSS) containerships alongside; (2) the development of Crane-on-Deck (COD) techniques and equipment for direct placement of cranes on the decks of NSS containerships to render them self-sustaining in an expedient manner; (3) the development of equipment and techniques to offload RO-RO ships offshore; and (4) the development of interface equipment and techniques to enable ship discharge by helicopters (either existing or projected in other development programs). The ship-to-shore subsystem includes: (1) the development of elevated causeways to allow cargo handling over the surf line and (2) development of self-propelled causeways to transport cargo from ships to the shore-side interface. The commonalty subsystem includes: (1) the development of wave

attenuating Tethered Float Breakwaters (TFB) to provide protection to COTS operating elements; (2) the development of special cranes and crane systems to compensate for container motion experienced during afloat handling; (3) the development of transportability interface items to enable essential outsize COTS equipment transport on merchant ships, particularly barge-ships; and (4) the development of system integration components such as moorings, fendering, communications, and services.

In conjunction with an investigation to determine the feasibility of COTS operations, analytical motion data involving three sea states are presented herein for containerships, lighter vessels, and rigid boom cranes.

SUMMARY

After the RAOs were predicted for three containerships and three lighter vessels, a containership and lighter pair were chosen which would yield motions representative of those encountered in COTS operations. Using Pierson-Moskowitz and Bretschneider sea spectra, significant surge, heave, sway, pitch, roll, and yaw motions were predicted. Relative displacements, velocities, and accelerations between a boom tip attached rigidly to the containership and the lighter center of gravity are presented for several crane boom positions and geometries. In addition, absolute boom tip motions were also predicted. Tables of these motions are presented for the many configurations investigated, and a sample procedure included indicating how these data are used for COTS analysis. The generation of the motions provides data for use in the trade-off design and analysis of the COTS and fulfills the objective of this study.

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INTRODUCTION

The COTS program investigates the feasibility of cargo transfer ashore from non-self-sustaining containerships at sea where port and offload facilities are not available. This concept involves the installation and use of a shipboard crane to convey up to 40-ton cargo containers to small, light vessels (lighters) which will then carry them ashore.

The system must be designed to operate in environments as high as sea state 3 without significant damage to the cargo, crane, or lighter vessel. An otherwise routine task in a static, land-based situation, the introduction of the relative ship motion factor requires analysis of the proposed system from a dynamic point of view. Compensation for this relative vertical motion between the crane-borne load and the lighter deck must be provided to reduce impact velocity at load touchdown.

In order to investigate the total dynamic problem, a group of mathematical models was developed to simulate all elements of the system and its operational environment. These include seaway, ship motion, crane structure, and crane control.[1] [2] [3] Using ship geometry data,[4] the ship motion model is exercised for several containerships and lighters to predict Response Amplitude Operators (RAOs) for head, quartering, and beam seas. These RAOs are then combined with Pierson-Moskowitz and Bretschneider sea spectra models to produce absolute and relative ship motions for a selected containership and lighter vessel. For selected crane configurations on board the containership, rigid boom tip motions and relative motions between the boom tip and the lighter craft are predicted as functions of wave heading, crane position, and crane geometry. These data are presented in tabular form for use in COTS system design trade-off analyses.

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[1]Naval Coastal Systems Center Technical Note 412, "Ship Motion Model User's Manual for the Container Offloading and Transfer System (COTS)," by D. C. Summey and T. C. Watson, July 1977.

[2]Naval Coastal Systems Center Technical Note TN 413, "Control Systems Model User's Manual for the Container Offloading and Transfer System (COTS)," by D. C. Summey and G. J. Dobeck, August 1977.

[3]Naval Coastal Systems Center Technical Note TN 478, "Structures Model for the Container Offloading and Transfer System (COTS)," by N. S. Smith and D. C. Summey, March 1979.

[4]Naval Coastal Systems Center Technical Note TN 415, "Preparation of Input Data for COTS Ship Motion Study," by D. C. Summey and T. C. Watson, April 1977.

SHIP AND LIGHTER RESPONSE AMPLITUDE OPERATORS

Following an extensive math modeling effort at the Naval Coastal Systems Center (NCSC), two major ship motion computer programs were used to generate RAO data. The MIT 5-D Seakeeping Program predicts RAOs for general ship heading with greater accuracy than the Naval Civil Engineering Laboratory Program, Relative Motion (RELMO)[1 5] but neglects surge computation. To provide motion data in all six degrees of freedom, the NCSC developed procedure predicts surge RAOs with RELMO and then combines the results with those of the MIT 5-D program. As discussed in later sections of the report, CTRADE uses the predicted RAO data to compute rigid boom motions and relative motion data for containerships, lighters, and crane geometries of interest.

Ship motion RAOs were predicted for each of three containerships and three lighters listed in Table 1; each vessel was considered to be within the range of vessel sizes identified for the COTS operation. The C5S73B, C6S85A, and C7S88A containerships were analyzed in both lightly and heavily loaded conditions to evaluate the effect of cargo on vessel response. Surge, heave, sway, pitch, roll, and yaw RAOs were computed for head, quartering, and beam seas for each vessel (refer to comparative plots in Figures 1 through 9).

RAOs offer a convenient approach for comparison of ship motions in the frequency domain without specifying the exact seaway forcing function. Examination of Figures 1 through 3 and 4 through 6 reveals a remarkable similarity between corresponding RAOs. Conclusively, the RAOs for the C6 and C7, with the exception of roll, are generally seen to be within the same envelope as those for the C5. In the case of roll, the C5 has a larger peak value but a different peak frequency. With the exception of roll, the C5 would therefore exhibit more ship motion than the C6 and C7 for a given sea spectrum. If the sea spectrum is chosen so that the energy is concentrated at the roll peak frequencies for the three containerships, then the C5 would also exhibit more roll motion than would either the C6 or C7 for spectra peaked at their respective roll peaks.

These comparisons indicate that the motions of the C6 and C7 will be no greater than those of the C5. Thus, in order to establish system design criteria, only motions for the C5S733 need be computed at various seaway and heading conditions. The conclusion that the C5 response is larger for all motions is based on the assumption that the peak frequency of the sea spectrum is selected to coincide with the peak frequency of the dominant ship RAO being considered (usually pitch or roll). A similar comparison between loading conditions revealed the lightly loaded C5 response to be more than the heavily loaded vessel.

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[1] ibid.

[5] Naval Coastal Systems Center Technical Memorandum TM 342-82, "Comparison of Computed Response Amplitude Operators for Containerships, Lighters, and Barges," by D. C. Summey and T. C. Watson, February 1982.

TABLE 1

CARGO AND LIGHTER VESSELS CONSIDERED IN COTS STUDY

Vessel	Length[1] (ft)	Beam (ft)	Draft (ft)	Displacement (long tons)
C5-S-73B[2]	581.83	78.00	29.62	24,655
C5-S-73B[3]	552.74	78.00	19.08	14,766
C6-S-85A[2]	625.00	90.00	31.42	28,520
C6-S-85A[3]	593.75	90.00	21.51	17,697
C7-S-88A[2]	677.00	95.00	33.72	38,256
C7-S-88A[3]	643.15	95.00	23.70	23,510
LCM-8	56.17	20.98	2.31	50
LCU-1610	124.95	29.00	2.90	185
3x15 Pontoon Causeway	90.00	21.00	1.40	55

[1]Load water line length

[2]Heavy condition

[3]Light condition

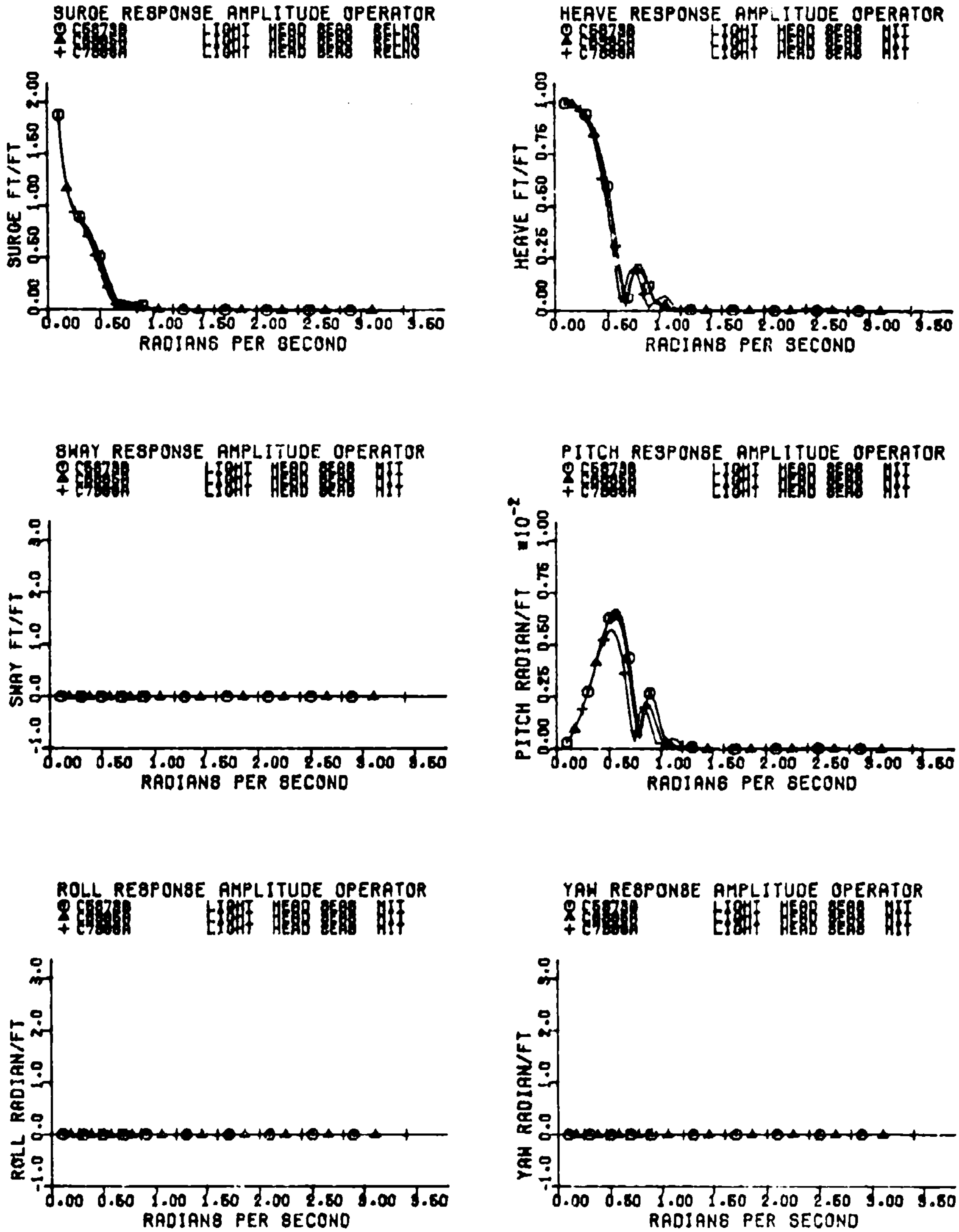

FIGURE 1. RAOs FOR THE C5, C6, AND C7 CONTAINERSHIPS IN THE LIGHTLY LOADED CONDITION FOR HEAD SEAS

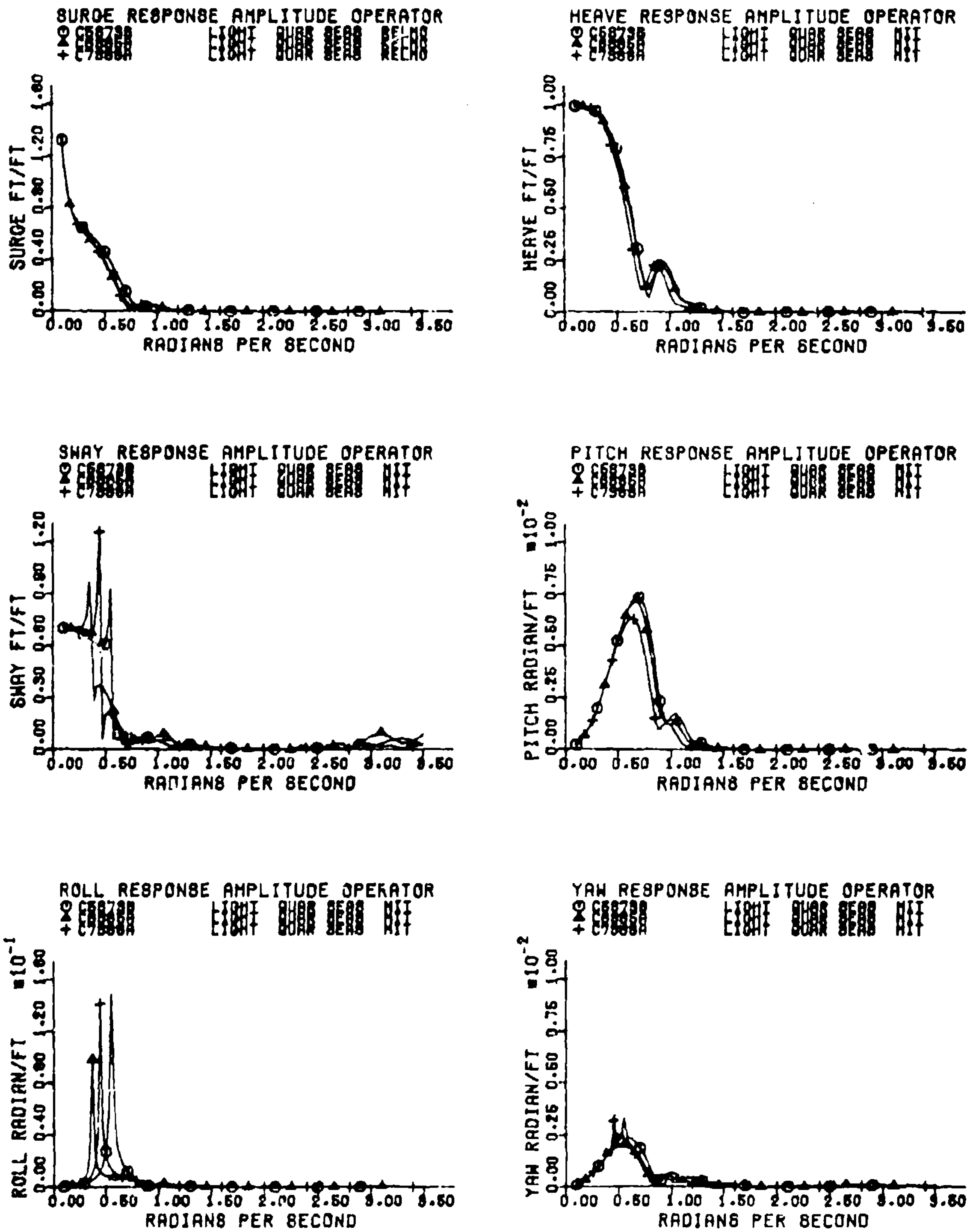

FIGURE 2. RAOs FOR THE C5, C6, AND C7 CONTAINERSHIPS IN THE LIGHTLY LOADED CONDITION FOR QUARTERING SEAS

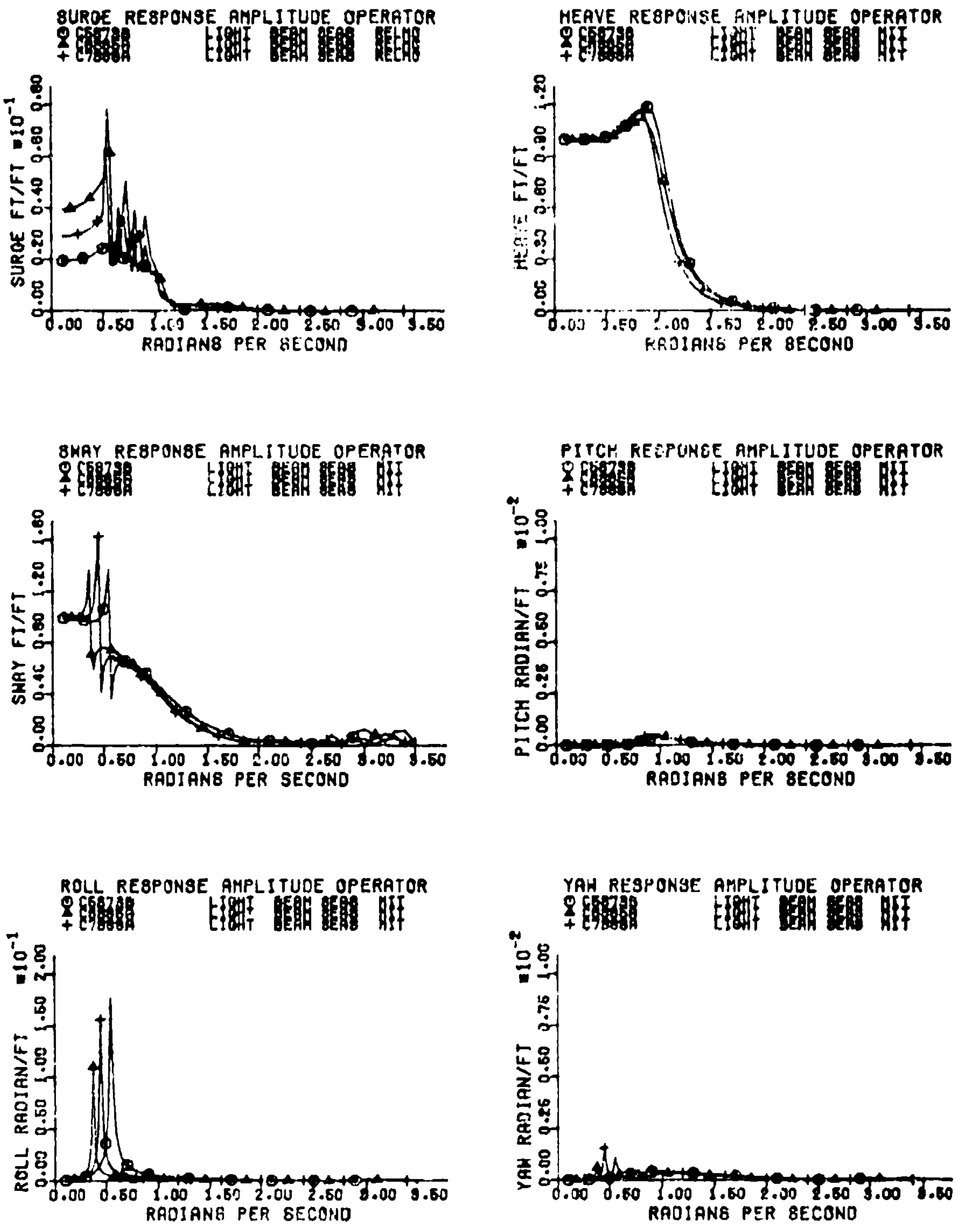

FIGURE 3. RAOs FOR THE C5, C6, AND C7 CONTAINERSHIPS IN THE LIGHTLY LOADED CONDITION FOR BEAM SEAS

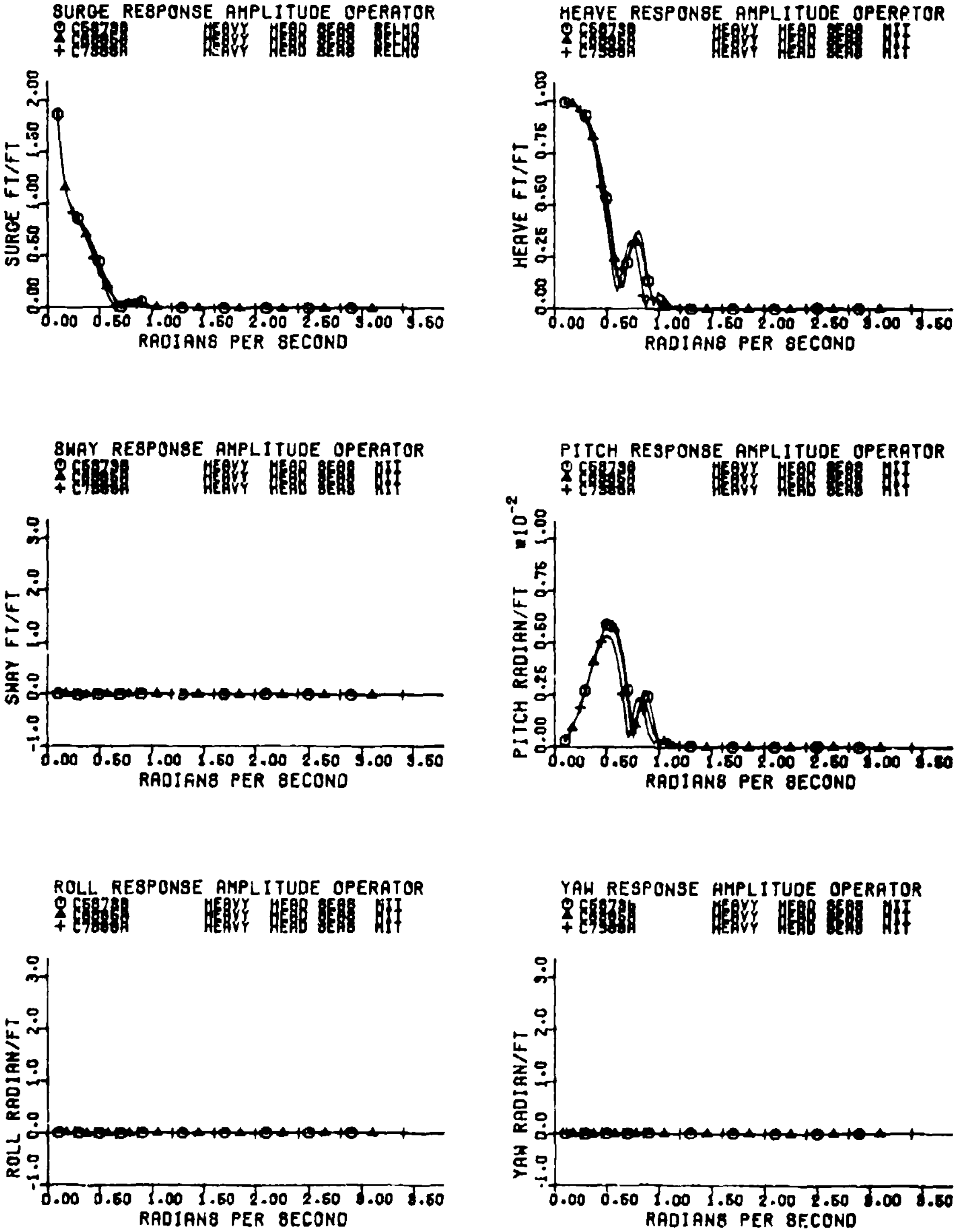

FIGURE 4. RAOs FOR THE C5, C6, AND C7 CONTAINERSHIPS IN THE HEAVILY LOADED CONDITION FOR HEAD SEAS

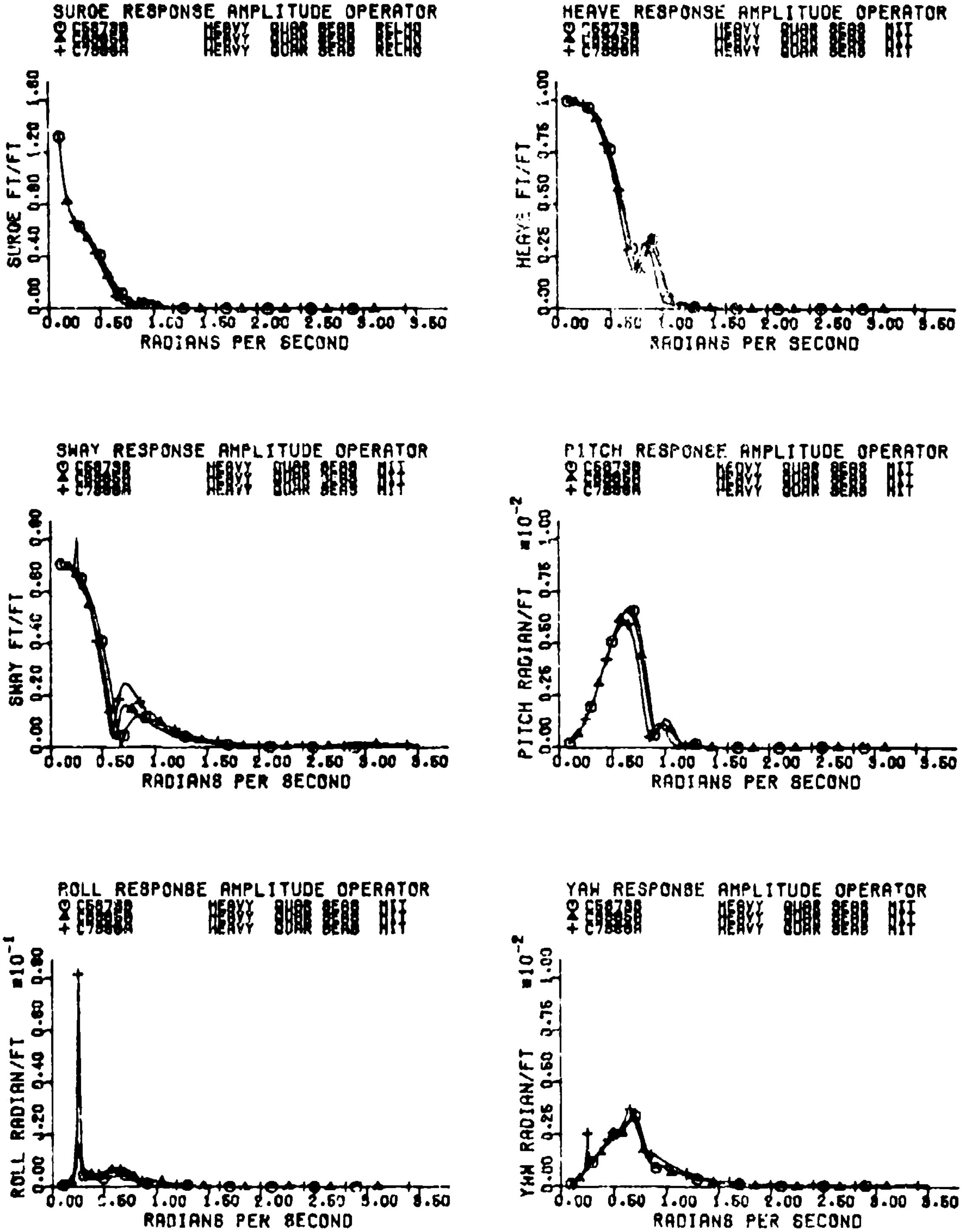

FIGURE 5. RAOs FOR THE C5, C6, AND C7 CONTAINERSHIPS IN THE HEAVILY LOADED CONDITION FOR QUARTERING SEAS

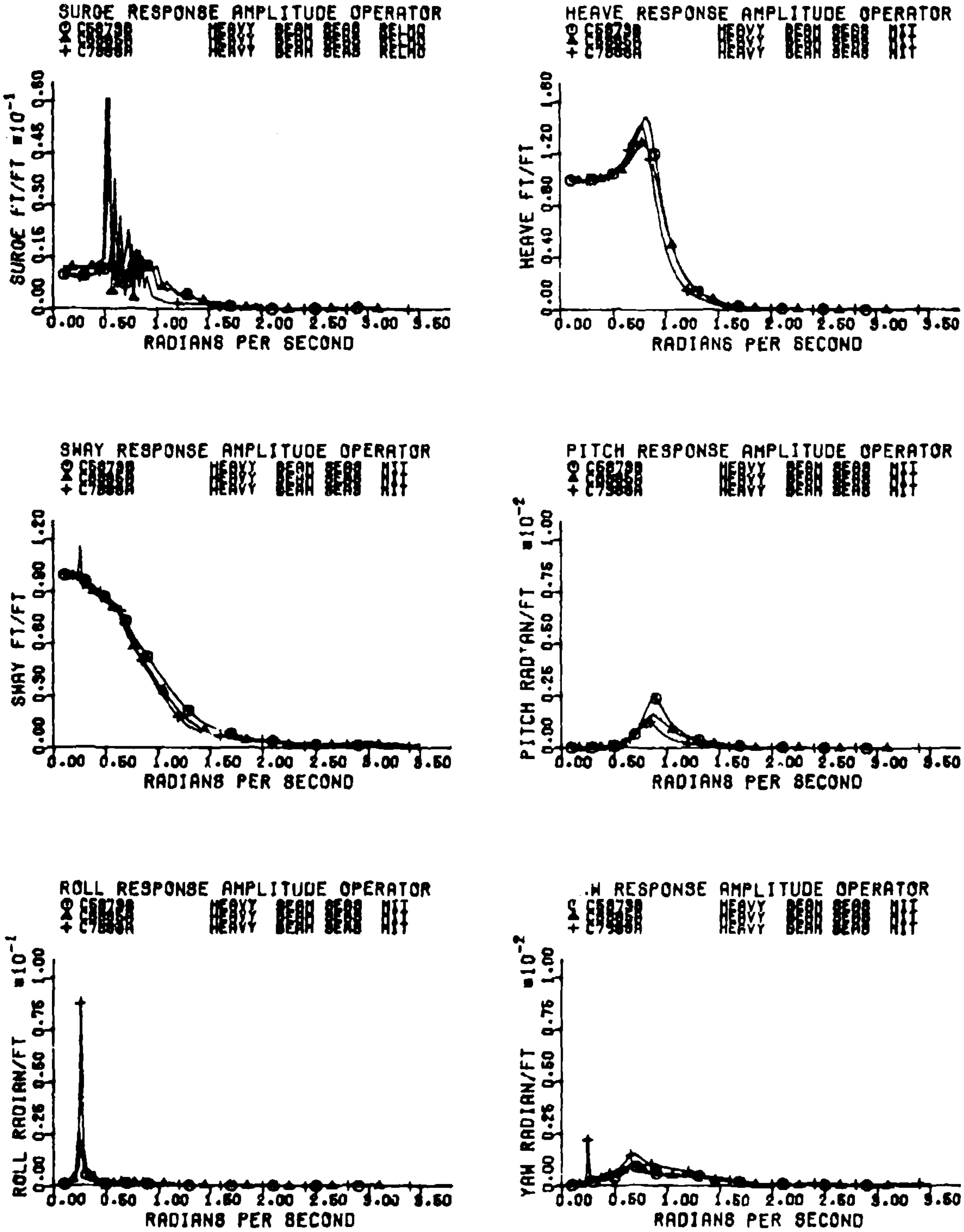

FIGURE 6. RAOs FOR THE C5, C6, AND C7 CONTAINERSHIPS IN THE HEAVILY LOADED CONDITION FOR BEAM SEAS

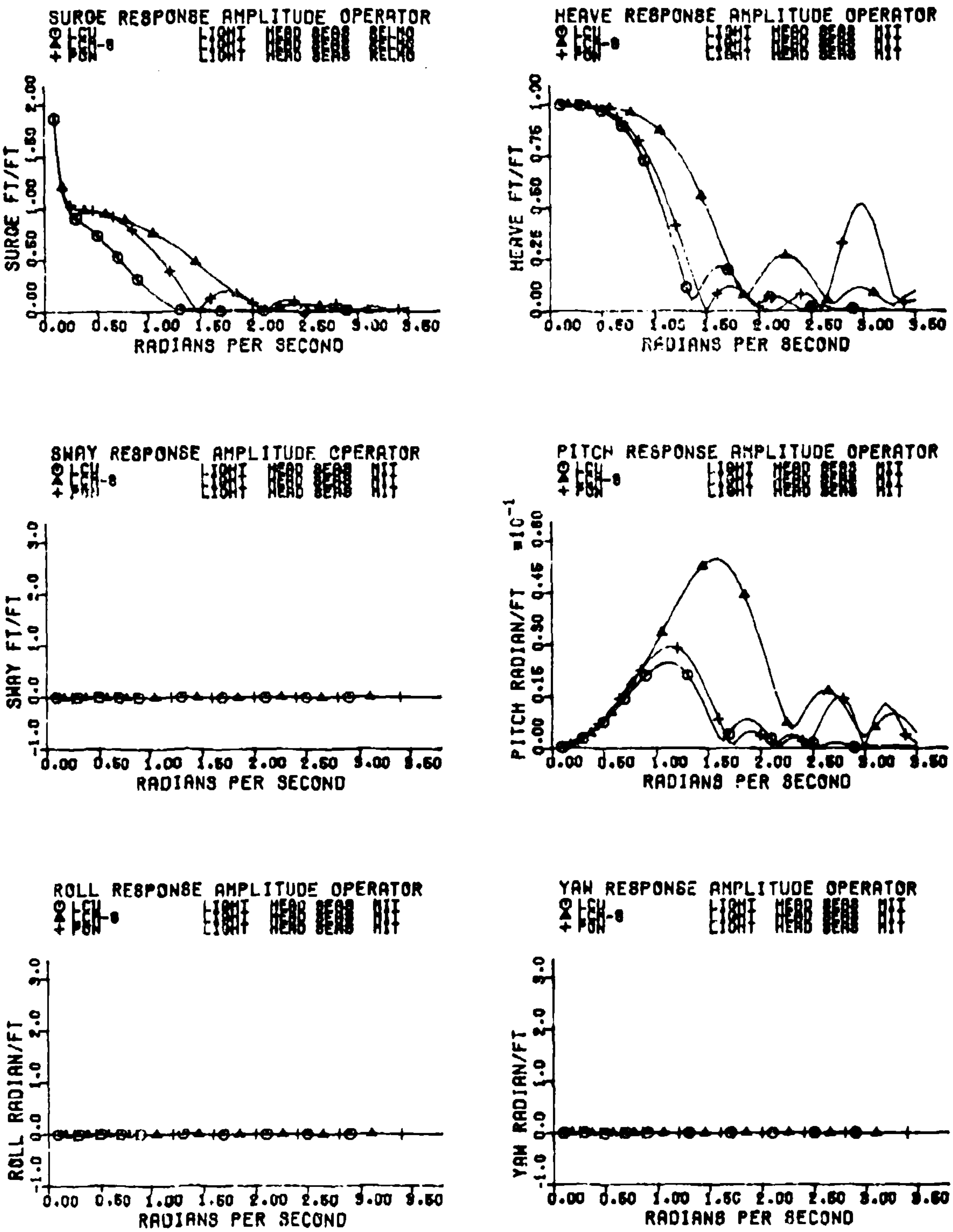

FIGURE 7. RAOs FOR THE LCU, LCM-8, AND PONTOON LIGHTERS IN THE LIGHTLY LOADED CONDITION FOR HEAD SEAS

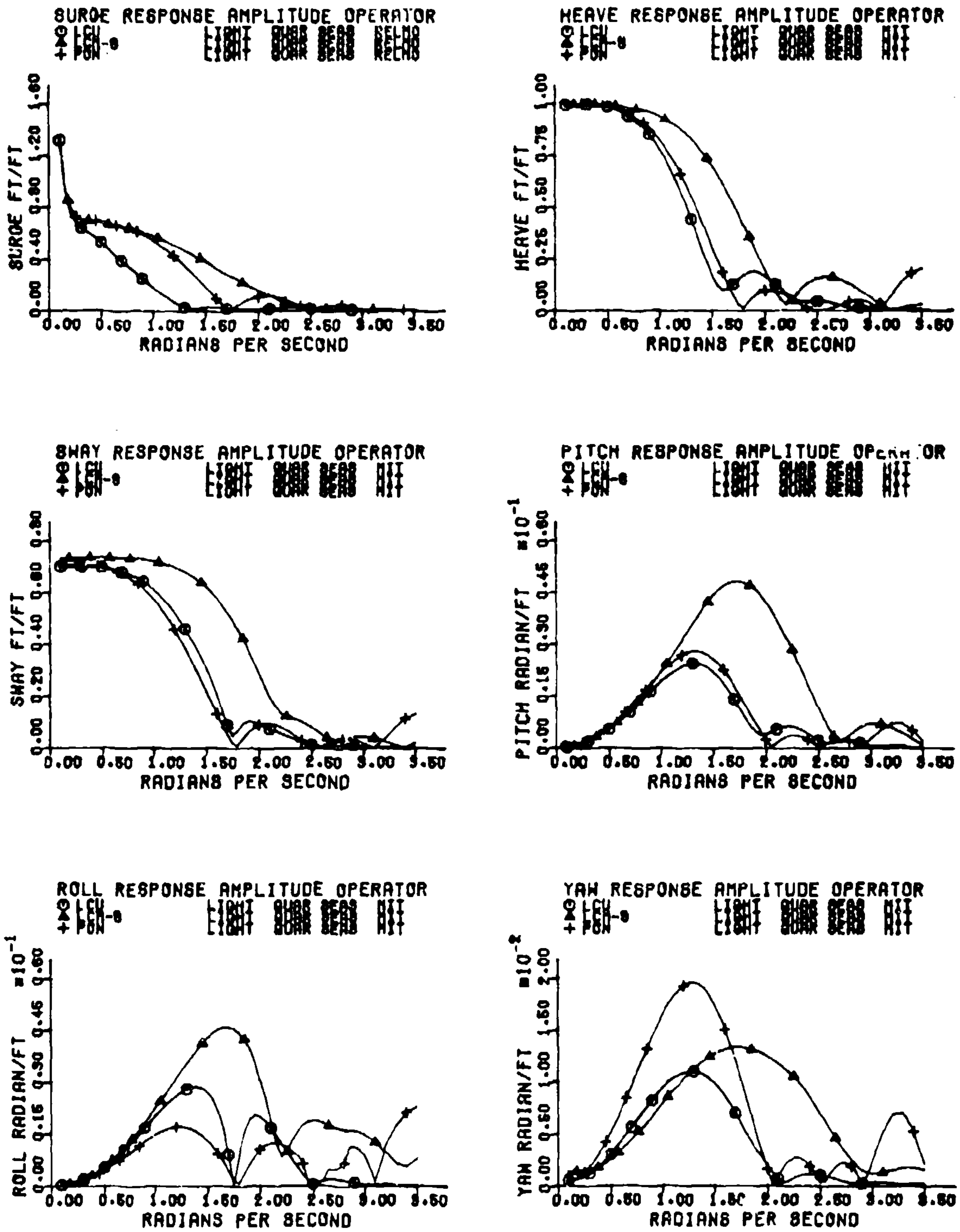

FIGURE 8. RAOs FOR THE LCU, LCM-8, AND PONTOON LIGHTERS IN THE LIGHTLY LOADED CONDITION FOR QUARTERING SEAS

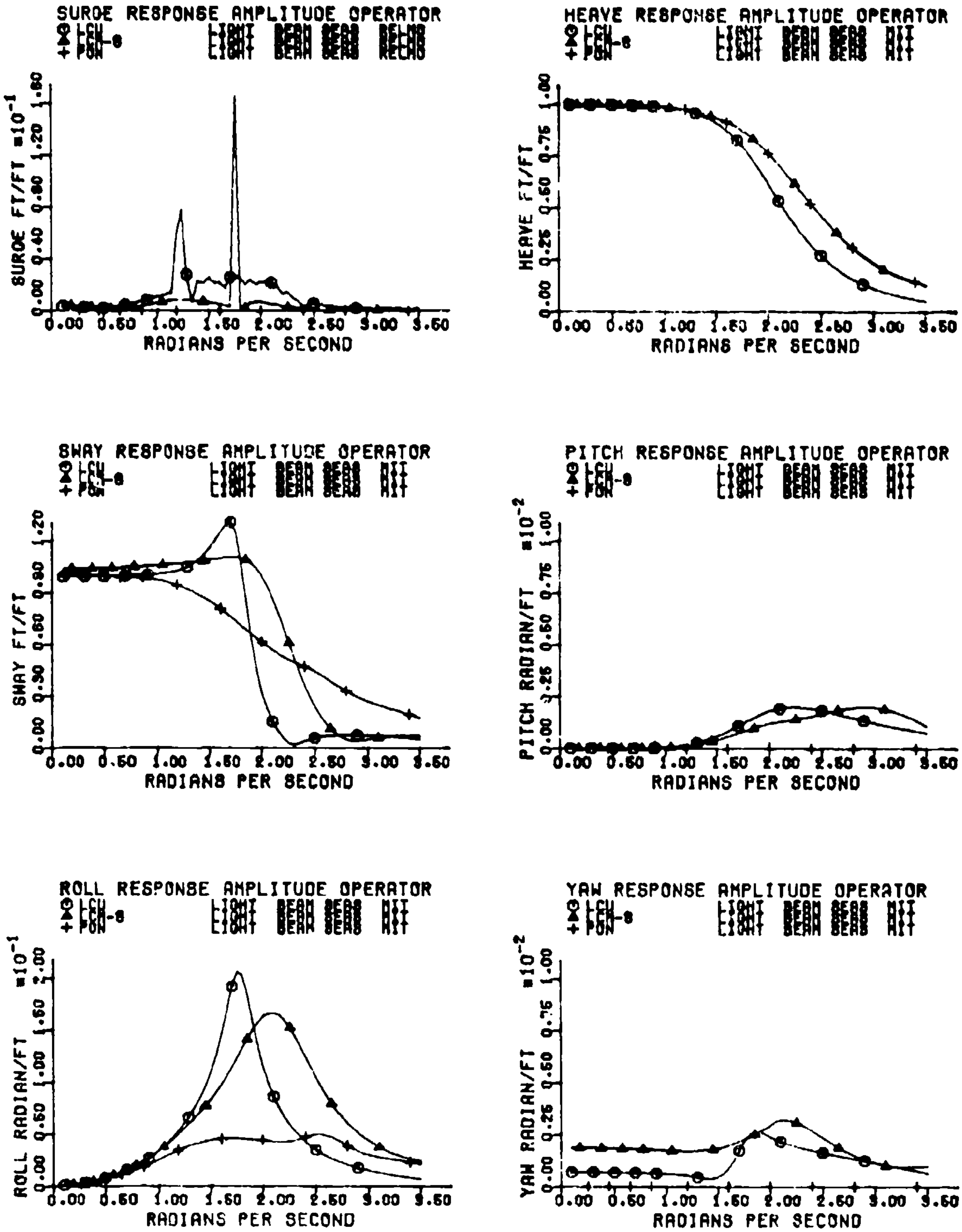

FIGURE 9. RAOs FOR THE LCU, LCM-8, AND PONTOON LIGHTERS IN THE LIGHTLY LOADED CONDITION FOR BEAM SEAS

In Figures 7 through 9, a comparative analysis of the lighter RAOs indicates that generally the Landing Craft Mechanized-8 (LCM-8) motions will be similar to those of the pontoon, and the Landing Craft Utility (LCU) motions will be no greater than those of the LCM-8. As a result of this comparison, rather than analyze the motions of each lighter vessel, motion data will be generated only for the LCM-8 lighter craft.

As a result of the overall RAO comparisons, the C5S73B and the LCM-8 were chosen for an in-depth motion analysis with various ship and crane geometries and seaway models. Typical relative motion RAOs for head seas as produced by the NCSC CTRADE program[1] for these two crafts are presented in Figure 10. These data represent relative motion displacement, velocity, and acceleration responses in each of the three coordinate directions between a point chosen on the C5 and a point on the LCM-8. The three points chosen in Figure 10 correspond to the lighter vessel center of gravity and the mid-ship, fore, and aft quarter points on the containership. It should be noted that for the relative motion RAOs it is assumed that there is no interaction between the two vessels of interest.

COTS SEA SPECTRUM MODEL

The RAO data presented in the previous section are transformed into motion data when combined with a sea spectrum model. The seaway model programmed into the COTS ship motion model will now be discussed.

The Seaway is a superposition of many regular waves of different amplitudes, frequencies, and phases traveling in different directions.[6 7 8] Since ship motion programs are not capable of analysis with multi-directional spectra, a unidirectional sea in which all waves are assumed to come from one direction is considered adequate for this analysis. In general, the sea is composed primarily of two types of waves: (1) high frequency, wind generated waves represented by a high frequency band of energy and (2) lower frequency

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[1]ibid.

[6]Ochi, M. K. and Bolton, W. E., "Statistics for Prediction of Ship Performance in a Seaway (Parts I, II, and III)," International Shipbuilding Progress; Vol. 20, February 1973, No. 222, vol. 20, April 1973, No. 224; Vol. 20, September 1973, No. 229.

[7]Michel, W. H., "Sea Spectra Simplified," Marine Technology, January 1968, pp. 17-30.

[8]Massachusetts Institute of Technology Report No. 70-3, "Computer Aided Prediction of Seakeeping Performance in Ship Design," by T. A. Loukakis, COM-71-00590, August 1970.

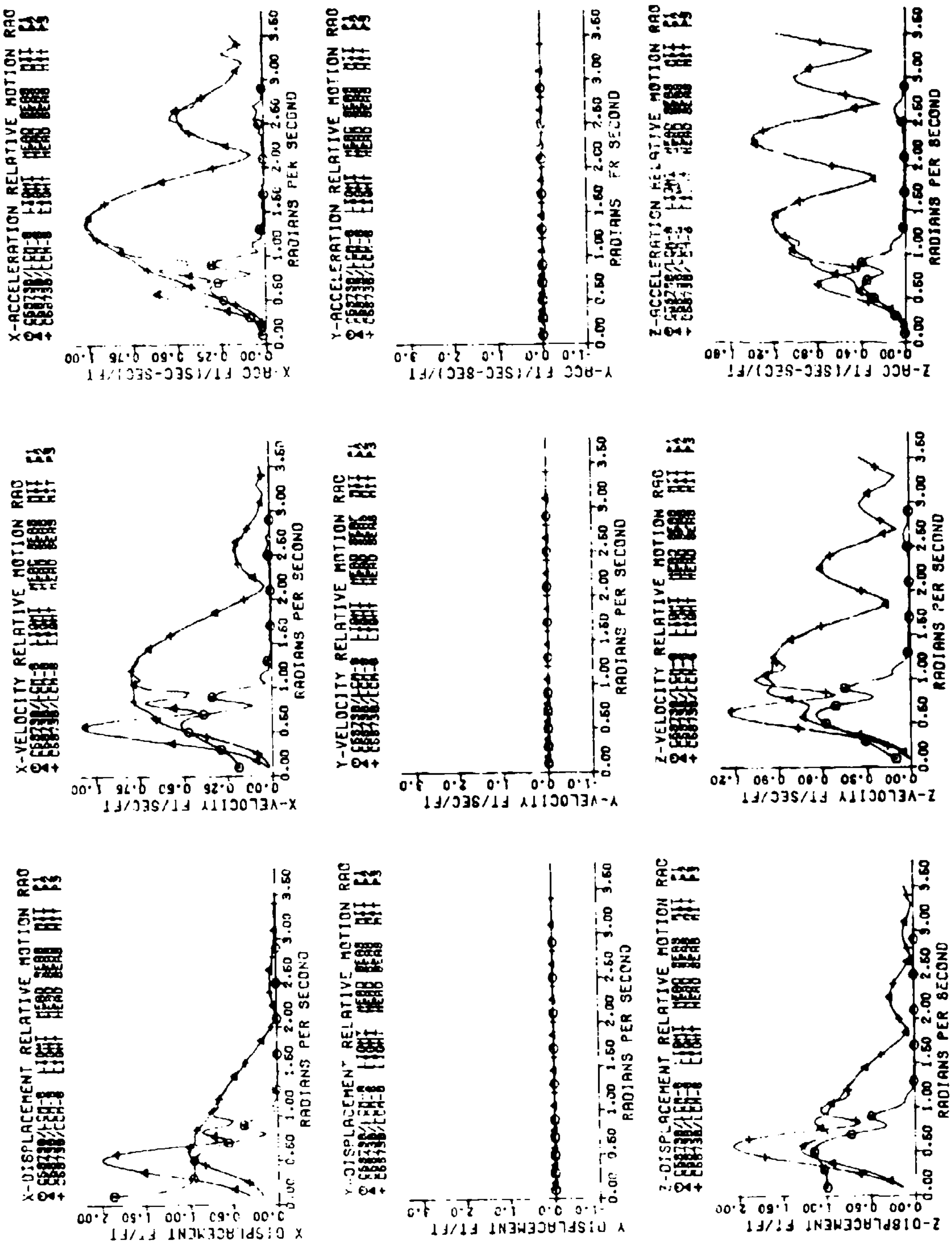

FIGURE 10. RELATIVE MOTION RAOs BETWEEN THE C5S73B AND THE LCM-8

swell waves, usually characterized by a single frequency narrow energy band. The severest seaway in which the cargo transfer system is required to operate is an upper sea state 3. This seaway is characterized, on the average, by 5-foot significant wave heights, 2.5 to 8.8-second wave periods, and 32 to 400-foot wave lengths, with an average wave height, wave period, and length of 3.3 feet, 4.8 seconds, and 200 feet. In lower sea states, the seaway exhibits lower wave heights, faster periods, and shorter wave lengths; the opposite is true in higher sea states.

The most widely used unidirectional spectra are the Pierson-Moskowitz and Bretschneider. Both spectra have a single peak and the general form

$$S(\omega) = \alpha\, \omega^{-5} \exp(-\beta\, \omega^{-4})$$

where

$\alpha = 5\, \omega_p^4\, (H^{1/3})^2/16$

$\beta = 5\, \omega_p^4/4$

$H^{1/3}$ = significant wave height (feet)*

ω_p = frequency where $S(\omega)$ is maximum (radians per second)

ω = frequency in radians per second.

Both $H^{1/3}$ and ω_p are independent parameters in the Bretschneider model where the Pierson-Moskowitz is a function only of significant wave height. The word "height" signifies the distance from the trough (low point of the wave) to the wave peak within one wave cycle, and $H^{1/3}$ is the average of the one-third largest heights. The word "average" indicates that the significant wave height is a statistical quantity. The peak frequency for the Pierson-Moskowitz is given by the following function of $H^{1/3}$:

$$\omega_p = 0.401 \sqrt{g/H^{1/3}}$$

where

g = 32.2 ft/sec^2 (acceleration of gravity).

The Bretschneider spectrum is defined in terms of peak frequency and significant wave height. When peak frequency data are available, the two parameter Bretschneider may provide a better description of the seaway than the single parameter Pierson-Moskowitz.

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*Throughout this report wherever significant wave heights ($H^{1/3}$, $H^{1/10}$, etc.) are referred to, the units are feet unless otherwise indicated.

As the significant wave height, $H^{1/3}$, is defined as the average of the 1/3 highest waves; $H^{1/10}$, $H^{1/100}$, and $H^{1/1000}$ are similarly defined as the average 1/10, 1/100, and 1/1000 highest waves. These statistics can be related to the seaway energy and are summarized as:

$$H^{1/3} = 4\sqrt{m_o}$$

$$H^{1/10} = 5.085\sqrt{m_o}$$

$$H^{1/100} = 6.664\sqrt{m_o}$$

$$H^{1/1000} = 7.712\sqrt{m_o}$$

The probability that a wave height will exceed the average height is 13.5 percent, 3.9 percent, 0.4 percent, and 0.1 percent for α equal to 1/3, 1/10, 1/100, and 1/1000. These statistics are useful in determining upper limits and worst case probabilities for random ship motions.

Deciding which spectrum to use for computing ship motion poses many difficulties. Since the energy of the seaway, m_o, is considered a fixed quantity in terms of sea state, the area under the spectrum can be specified with certainty. However, the distribution of energy in frequency is not readily specifiable. Spectral analysis of actual sea data shows that spectrum shape varies greatly from one geographical location to another as a function of weather, time of year, time of day, and ocean depth. It is conceivable that a spectrum could be accurately specified for one geographical location, one season, one time of day, one weather condition, and one ocean depth; but many spectra are needed to develop data for general COTS design criteria.

The only approach that seemed reasonable was to predict motion for several spectra. These spectra would correspond not only to spectra exciting the cargo ship at its natural frequencies of pitch and roll, but also to the conventional Pierson-Moskowitz spectrum. In addition, a special very narrow band spectrum with the energy of a 1-foot high wave was superimposed on the normal Bretschneider spectrum in an attempt to model the effect of swell. It should be noted that the swell modification increases the significant wave height from 5.0 to 6.1 feet for a sea state 3. Using these spectrum types, ship motions, relative motions, and rigid boom crane motions were computed to provide motion data characteristic of proposed COTS operations. Figure 11 provides the results of the spectra investigation and relates the following correspondence:

1. Pierson-Moskowitz spectra with significant wave heights of 3.0, 5.0, and 6.5 feet [upper sea states (2, 3, and 4)]

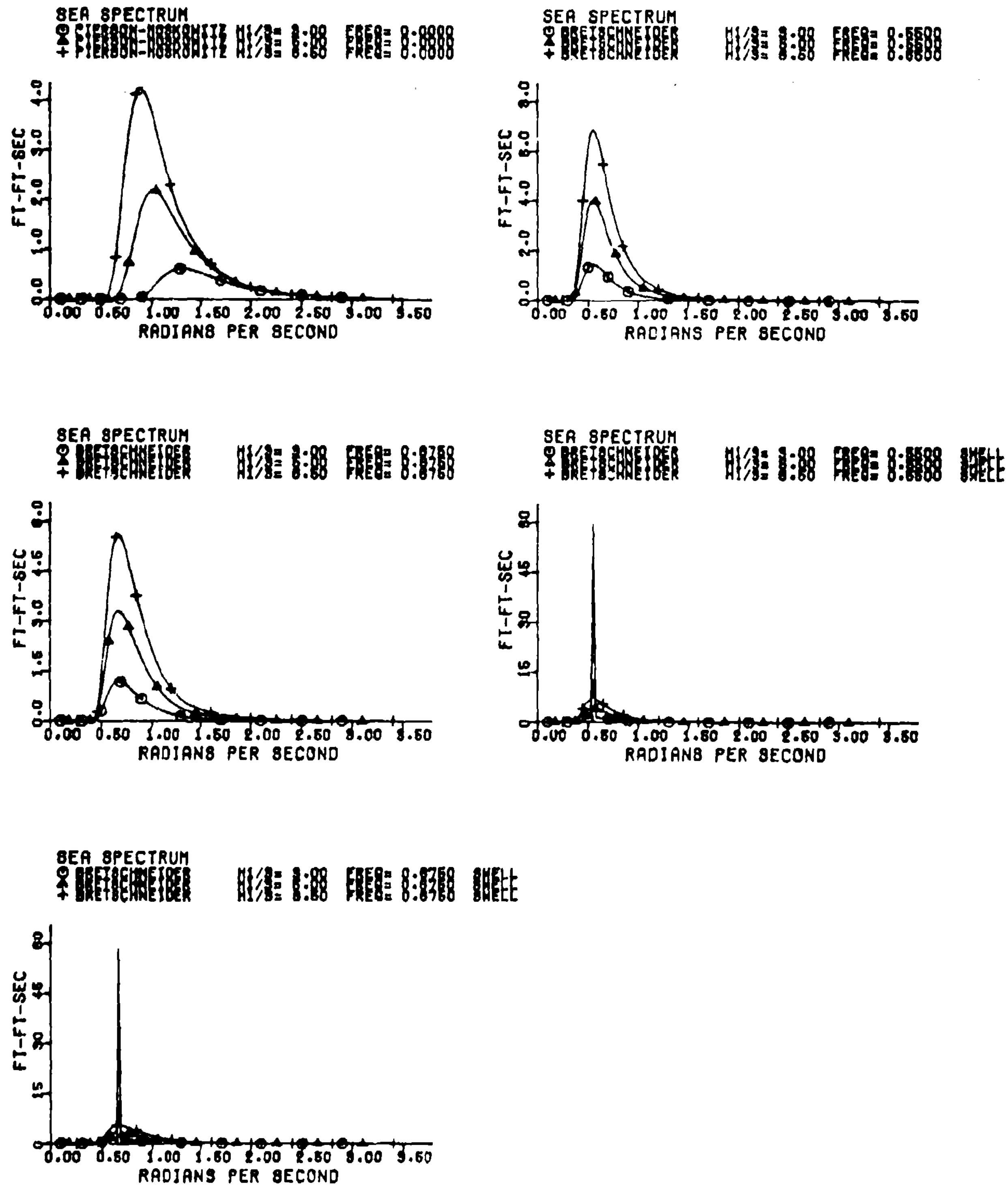

FIGURE 11. SEA SPECTRA USED IN THE COTS ANALYSIS

2. Bretschneider spectra with a peak frequency of 0.55 radian per second corresponding to the C5 resonant roll frequency (Figures 2 and 3) and significant wave heights of 3.0, 5.0, and 6.5 feet

3. Bretschneider spectra with a peak frequency of 0.675 radian per second corresponding to the C5 resonant pitch frequency (Figures 1 and 2) and significant wave heights of 3.0, 5.0, and 6.5 feet

4. Bretschneider spectra described in paragraph 2 with a 1-foot swell superimposed at 0.55 radian per second and significant wave heights of 3.0, 5.0, and 6.5 feet

5. Bretschneider spectra described in paragraph 3 with a 1-foot swell superimposed at 0.675 radian per second and significant wave heights of 3.0, 5.0, and 6.5 feet.

These spectra correspond to those which, in general, excite the cargo vessel rather than the lighter craft. Those spectra which would excite the lighter craft have higher frequency waves which would not excite the cargo vessel, and would therefore generate less relative motion. The lower frequency waves which excite the cargo ship, however, also excite the lighter craft which tend to follow the waves. Thus, the spectra which excite the cargo ship are the spectra which produce the largest relative motions for the system, a factor especially true when computing the motion of a crane boom rigidly attached to the cargo vessel.

Although Pierson-Moskowitz and swell spectra data are valid only at specified wave heights, the Bretschneider data can be scaled to provide motions for different significant wave heights at the same peak frequency. For example, if a pitch motion for head seas (corresponding to a Bretschneider spectrum of 5 feet peaked at 1.0 radian per second) is 1.5 degrees, the motion for a Bretschneider spectrum peaked at the same frequency with a wave height of only 2.5 feet would be (1.5)(2.5)/(5.0) = 0.75 degree. This linear scaling technique can be used to predict motions for any significant wave height spectra at the specified Bretschneider peak frequencies.

SHIP AND RIGID BOOM MOTION DATA

In addition to ship motions (surge, heave, sway, pitch, roll, and yaw), the CTRADE program also provides the capability to compute displacement, velocities, and accelerations in each of the three coordinate directions for any data point considered to be rigidly attached to the ship center of gravity.

The previously presented RAO data and sea spectra models were therefore combined to predict absolute ship motion for the C5S73B and the LCM-8; relative motions between the craft; and rigid boom tip displacement, velocity, and acceleration motions in the three coordinate directions for a crane in different geometry configurations rigidly attached to the cargo ship. The motion

data, much of which is categorized as phased and worst case, is presented in tabular form for the different sea spectra and wave incidence angles (headings) of interest. The phased data corresponds to using the phase angle information produced with the RAO data by the ship motion program in computing displacements, velocities, and accelerations. Worst case motions correspond to the assumption that the phase angles are all zero, thus yielding maximum possible values for the displacements, velocities, and accelerations computed from surge, heave, sway, pitch, roll, and yaw. The capability to compute worst case motions was incorporated into the CTRADE program for two reasons: first, the agreement of computed phase angles is not nearly as well documented for ships as are the RAO data; and second, cancellation effects computed with inaccurate phase angles may produce motions which are much less than the values with appropriate phase angles. Therefore, if the phased motion and the worst case motion computations differ greatly, the more conservative worst case data may be more appropriate for input into the COTS design and trade-off analysis.

The ship motion responses of the C5S73B and the LCM-8 are presented as functions of heading in Tables 2, 3, and 4. The responses of the vessels to Pierson-Moskowitz spectra at sea states 2, 3, and 4 are presented in Table 2. In Table 3, significant ship motions for quartering seas are presented for the five spectra discussed in the previous section. For the containership, the motions excited with spectra 2 and 3 can be seen in Table 3 to be generally less than those for spectra 4 and 5. While this trend does not always apply to the lighter craft, its motions are of the same order for similar spectra. Thus, in order to reduce the amount of data while still bounding expected motions, general motion data will only be presented for the Pierson-Moskowitz and both roll Bretschneider spectra. Although only quartering sea data are presented in Table 3, the same trends are evident for head and beam seas. Thus, if motion data are desired for the Bretschneider spectra peaked at the pitch RAO peak frequency, data for the similar roll peak will be the upper bound for the containership. The data set presented in Table 4 corresponds to the ship motions for head, quartering, and beam seas for Pierson-Moskowitz, Bretschneider, and Bretschneider plus swell for a sea state 3.

The ship motion data, although valuable, is not the most useful form for estimating COTS motion compensation requirements; the data must be transformed into significant displacements, velocities, and accelerations along the three axes of the containership. The CTRADE program provides those types of data for any point attached rigidly to the C5 and for any point on the C5 relative to another point on the LCM-8 lighter. By assuming the boom is a rigid member, boom tip motions for various crane configurations and positions and various sea spectra can be generated. Although this assumption is not strictly correct, in general these calculations will provide a good approximation to the boom tip dynamic motions. Using the rigid boom assumption and the relative motion capability of the mathematical model, trade-off data were computed to evaluate the effects of crane geometry and deck placement for several crane, ship, and lighter configurations.

The matrix of geometric quantities considered in the motion analysis are described in Figure 12. These quantities include the effects of boom elevation angle above the deck (45, 60, and 75 degrees), boom slue angle off the

TABLE 2

SIGNIFICANT ($H^{1/3}$) C5S73B AND LCM-8 MOTIONS FOR PIERSON-MOSKOWITZ SPECTRA

C5S73B Containership	Pierson-Moskowitz Spectra
(Lightly Loaded)	1 $H^{1/3}$ = 3.0
LCM-8 Lighter	2 $H^{1/3}$ = 5.0
(Lightly Loaded)	3 $H^{1/3}$ = 6.5

Ship Motions	Spectra Type	Containership Motions			Lighter Motions		
		Head	Quarter	Beam	Head	Quarter	Beam
Surge (ft)	1	0.01	0.02	0	0.70	0.57	0.04
	2	0.06	0.08	0.02	1.63	1.23	0.05
	3	0.13	0.19	0.04	2.36	1.75	0.05
Heave (ft)	1	0.03	0.08	0.53	0.81	0.98	1.29
	2	0.19	0.30	1.80	1.84	2.03	2.33
	3	0.35	0.52	2.80	2.64	2.82	3.10
Sway (ft)	1	0	0.04	0.34	0	0.15	0.67
	2	0	0.10	0.95	0	0.63	2.22
	3	0	0.17	1.47	0	1.16	3.51
Pitch (deg)	1	0.03	0.05	0.01	3.64	3.18	0.07
	2	0.16	0.29	0.04	5.51	4.49	0.08
	3	0.33	0.60	0.05	6.43	5.13	0.08
Roll (deg)	1	0	0.08	0.18	0	2.99	8.19
	2	0	0.33	0.63	0	4.35	10.05
	3	0	1.05	1.51	0	5.01	10.86
Yaw (deg)	1	0	0.02	0.02	0	0.96	0.18
	2	0	0.07	0.05	0	1.42	0.27
	3	0	0.13	0.07	0	1.66	0.34

TABLE 3

SIGNIFICANT ($H^{1/3}$) C5S73B AND LCM-8 MOTIONS FOR QUARTERING SEAS AND FIVE SEA SPECTRA

Spectra Number	C5S73B Containership					LCM-8 Lighter				
	1	2	3	4	5	1	2	3	4	5
Surge (ft)	0.08	0.46	0.57	0.77	1.04	1.23	1.53	1.92	1.61	2.01
Heave (ft)	0.30	0.88	1.11	1.36	1.84	2.03	2.35	2.93	2.42	2.99
Sway (ft)	0.10	0.56	0.58	1.00	1.93	1.63	3.24	3.35	1.81	2.23
Pitch (deg)	0.29	0.76	1.06	0.80	1.01	4.49	2.80	2.98	2.09	2.20
Roll (deg)	0.33	4.66	4.89	6.63	16.45	4.35	2.77	2.96	2.08	2.20
Yaw (deg)	0.07	0.22	0.30	0.28	0.43	1.42	0.95	1.04	0.74	0.80

Spectra:

1. Pierson-Moskowitz, $H^{1/3} = 5.0$
2. Bretschneider peaked at pitch peak (0.675 rad/sec), $H^{1/3} = 5.0$
3. Bretschneider peaked at pitch peak (0.675 rad/sec), $H^{1/3} = 5.0$ + swell peak
4. Bretschneider peaked at roll peak (0.55 rad/sec), $H^{1/3} = 5.0$
5. Bretschneider peaked at roll peak (0.55 rad/sec), $H^{1/3} = 5.0$ + swell peak

TABLE 4

SIGNIFICANT ($H^{1/3}$) C5S73B AND LCM-8 MOTIONS FOR PIERSON-MOSKOWITZ AND BRETSCHNEIDER SPECTRA

C5S73B Containership
(Lightly Loaded)
LCM-8 Lighter
(Lightly Loaded)

Spectra
Significant Wave Height = 5 Feet
1 Pierson-Moskowitz
2 Bretschneider (Roll Peak)
3 Bretschneider + Swell (Roll Peak)

Ship Motions	Spectra Type	Containership Motions			Lighter Motions		
		Head	Quarter	Beam	Head	Quarter	Beam
Surge (ft)	1	0.06	0.08	0.02	1.63	1.23	0.05
	2	0.82	0.77	0.06	2.25	1.61	0.02
	3	1.07	1.04	0.07	2.81	2.01	0.02
Heave (ft)	1	0.19	0.30	1.80	1.84	2.03	2.33
	2	0.95	1.36	2.56	2.38	2.42	2.47
	3	1.23	1.84	3.13	2.95	2.99	3.03
Sway (ft)	1	0	0.10	0.95	0	1.63	2.59
	2	0	1.00	1.97	0	1.81	2.61
	3	0	1.93	3.11	0	2.23	3.19
Pitch (deg)	1	0.16	0.29	0.04	5.51	4.49	0.08
	2	0.71	0.80	0.02	2.76	2.09	0.02
	3	0.98	1.01	0.02	2.92	2.20	0.02
Roll (deg)	1	0	0.33	0.63	0	4.35	10.05
	2	0	6.63	8.15	0	2.08	3.89
	3	0	16.45	19.73	0	2.20	4.01
Yaw (deg)	1	0	0.07	0.05	0	1.42	0.27
	2	0	0.28	0.06	0	0.74	0.26
	3	0	0.43	0.13	0	0.80	0.32

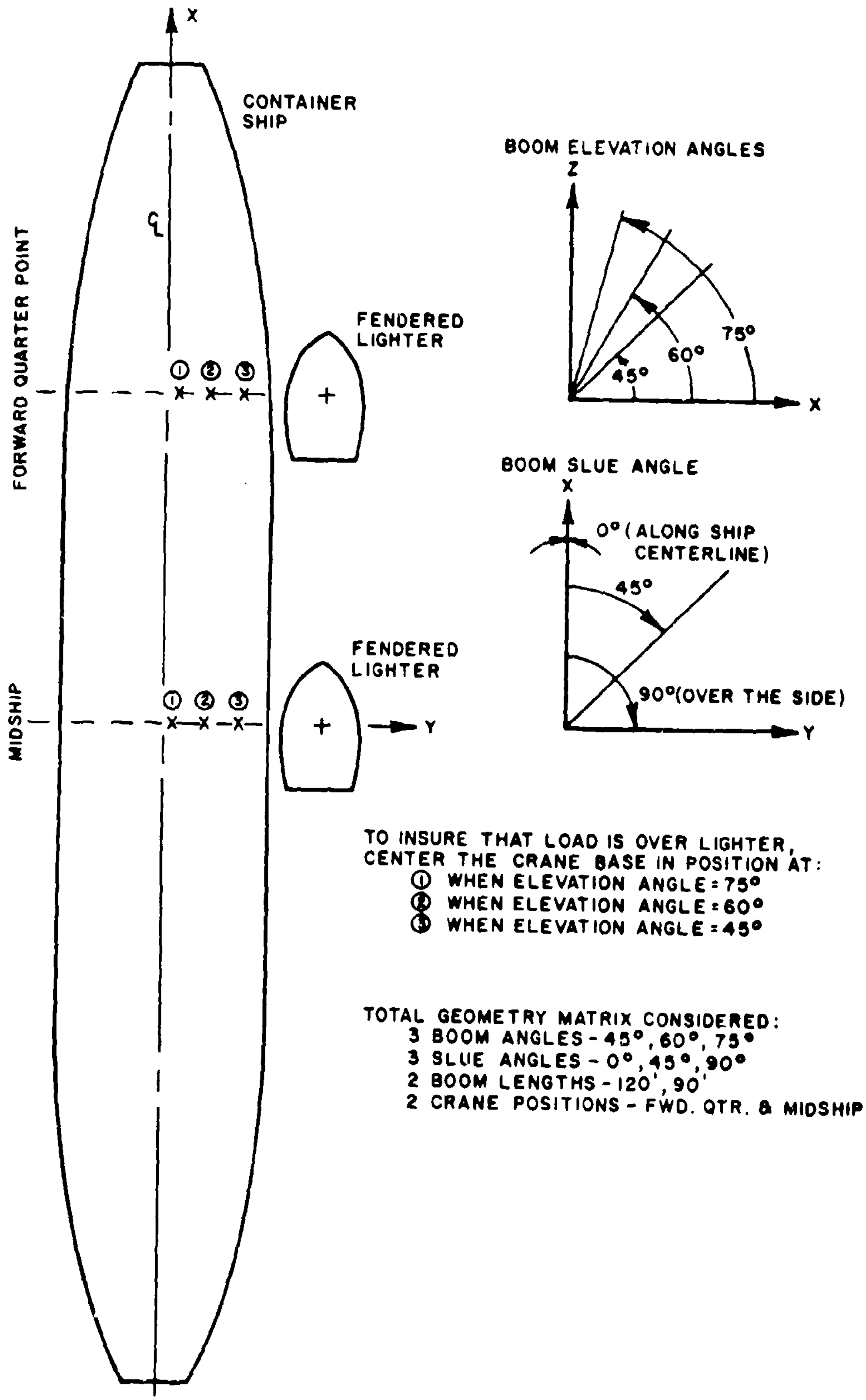

FIGURE 12. CRANE AND SHIP GEOMETRIES CONSIDERED IN RIGID BOOM TRADE-OFF ANALYSIS

ship centerline (0, 45, 90 degrees), boom length (90 and 120 feet), and crane position on the containership (mid-ship and forward quarter point). In order to minimize the amount of data presented, aft quarter point motions were omitted since they were generally less than those for the forward quarter point. Boom tip displacements, velocities, and accelerations were computed for each geometric configuration; and relative motions were computed between the boom tip and the lighter center of gravity for those configurations in which the boom tip (and the load because it would be located under the tip) was located directly above the lighter (slue angle of 90 degrees). The motions were predicted as a function of wave heading for head, quartering, and beam seas and for sea states 2, 3, and 4 with the Pierson-Moskowitz, Bretschneider, and Bretschneider plus swell spectra. Both phased and worst case data* were presented in Tables 5 through 24 for vertical, transverse, and longitudinal displacements, velocities, and accelerations. Although almost 10,000 data entries are presented in Tables 5 through 24, not all of the data for sea states 2 and 4 are presented. Tables 5 through 12 provide data for a 120-foot boom at the mid-ship and forward quarter points for sea state 3 ($H^{1/3}$ = 5.0), while Tables 13 through 16 present a subset of these same data for sea states 2 and 4 ($H^{1/3}$ = 3.0 and 6.5). Tables 17 through 24 present motion data for a 90-foot boom at the mid-ship and forward quarter points for sea state 3. At this point it should be noted that the Bretschneider spectra data are directly scalable as a function of significant wave height; however, the Pierson-Moskowitz spectra data are not scalable. Although not rigorous, approximations are also possible for data not presented by using linear interpolation between data values provided. For example, boom tip motions for a boom length of 105 feet should be approximately equal to the average of the motions for the 90- and 120-foot booms.

While this report is not intended to specify design requirements, the large volume of data presented in the tables is useful for determining design requirements for COTS. The following paragraph discusses a process by which these data may be used.

By examining both the RAOs and motion data, it is seen that quartering seas contain pitch motions as large as head seas and roll motions almost as large as beam seas. Since pitch and roll angular motions are important to the design criteria of COTS, it is likely that a system will work in head and beam seas if it is designed to meet the environment of quartering seas. Another factor in determining the design criteria is the choice of the design sea spectra. While the Pierson-Moskowitz spectra seem too limited for general design, it appears that the Bretschneider spectrum plus swell is too severe; therefore, the Bretschneider spectrum peaked at the roll peak is recommended. Using the quartering seas and the Bretschneider spectrum, Table 25 presents sample COTS design data for sea state 3 (significant wave height of 5.0). The same data for a significant wave height of 3.0 are obtained by multiplying the data in Table 25 by 0.6. These worst case data were gleaned from Tables 5 through 24 by noting which motions would correspond to boom in-plane and out-of-plane data. Similar data can be developed for other design requirements from the tabular motion data.

*The displacement, velocity, and acceleration data presented are significant amplitudes.

TABLE 5

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 120 FEET, BOOM ELEVATION OF 45°, $H^{1/3}$ = 5 FEET

CS-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 120'
BOOM ELEVATION = 45°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION, SLUE ANGLE = 0°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 380.77 y = 35.36 z = 155.71						TIP MOTION, SLUE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 290.92 y = -54.49 z = 155.71						RELATIVE MOTION, SLUE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 290.92 y = -54.49 z = 155.71					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.45	0.41	0.97	0.84	2.23	1.60	0.22	0.21	0.64	0.43	2.38	2.26	2.03	1.97	2.59	2.24	4.52	1.94
	2	1.45	1.15	4.64	3.41	5.39	3.76	0.63	0.55	5.27	4.77	7.17	6.61	2.92	2.59	6.94	5.71	9.16	5.65
	3	1.75	1.51	5.47	4.15	6.18	4.25	0.65	0.57	5.72	4.97	8.05	7.20	3.40	3.16	8.00	6.49	10.63	5.95
VERTICAL VELOCITY (FT/SEC)	1	0.40	0.36	0.85	0.73	2.15	1.52	0.19	0.18	0.58	0.41	2.28	2.19	2.17	2.11	2.79	2.47	4.85	2.48
	2	0.92	0.75	2.80	2.12	3.50	2.45	0.40	0.35	3.02	2.69	4.46	4.09	2.16	2.04	4.39	3.63	6.19	3.46
	3	1.13	1.00	3.42	2.66	4.05	2.79	0.41	0.36	3.38	2.85	5.10	4.52	2.53	2.39	5.14	4.18	7.18	3.68
VERTICAL ACCELERATION (FT/SEC^2)	1	0.36	0.36	0.79	0.66	2.16	1.50	0.17	0.16	0.55	0.41	2.25	2.21	2.54	2.48	3.30	2.99	5.94	3.73
	2	0.62	0.52	1.76	1.39	2.52	1.77	0.27	0.24	1.78	1.54	3.03	2.78	1.95	1.86	3.17	2.68	4.93	2.66
	3	0.77	0.69	2.21	1.76	2.87	1.98	0.28	0.25	2.05	1.67	3.45	3.07	2.13	2.03	3.65	3.02	5.51	2.79
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.10	0.82	2.71	2.62	0.00	0.00	1.00	0.86	2.64	2.59	0.00	0.00	2.51	2.15	5.12	2.01
	2	0.00	0.00	13.45	12.46	16.82	15.66	0.00	0.00	13.19	12.34	16.75	15.59	0.00	0.00	14.20	12.47	18.43	14.96
	3	0.00	0.00	14.19	13.10	17.94	16.86	0.00	0.00	13.83	13.00	17.86	16.77	0.00	0.00	15.22	13.51	20.11	15.59
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.98	0.67	2.62	2.49	0.00	0.00	0.89	0.72	2.54	2.47	0.00	0.00	2.69	2.27	5.69	2.67
	2	0.00	0.00	7.61	7.05	9.71	9.10	0.00	0.00	7.45	6.99	9.66	9.36	0.00	0.00	8.22	7.25	11.09	8.52
	3	0.00	0.00	8.20	7.57	10.58	10.03	0.00	0.00	7.96	7.52	10.52	9.98	0.00	0.00	9.01	8.05	12.35	9.03
TRANSVERSE ACCELERATION (FT/SEC^2)	1	0.00	0.00	0.97	0.59	2.73	2.54	0.00	0.00	0.86	0.65	2.64	2.51	0.00	0.00	3.24	2.70	7.29	4.11
	2	0.00	0.00	4.37	4.03	5.83	5.51	0.00	0.00	4.26	4.00	5.78	5.49	0.00	0.00	5.03	4.44	7.50	5.20
	3	0.00	0.00	4.83	4.44	6.48	6.23	0.00	0.00	4.66	4.42	6.43	6.15	0.00	0.00	5.62	5.03	8.35	5.57
LONGITUDINAL DISPLACEMENT (FEET)	1	0.49	0.47	0.89	0.82	0.15	0.12	0.49	0.47	0.91	[illegible]	0.16	0.07	2.08	1.45	2.06	1.08	0.18	0.09
	2	2.68	2.10	3.02	2.29	0.12	0.07	2.68	2.10	3.11	2.35	0.14	[illegible]	4.64	3.65	4.69	3.45	0.15	0.10
	3	3.68	2.87	3.95	2.88	0.17	0.08	3.68	2.87	4.11	3.03	0.21	0.13	6.42	5.10	6.09	4.59	0.22	0.17
LONGITUDINAL VELOCITY (FT/SEC)	1	0.44	0.42	0.76	0.71	0.15	0.13	0.44	0.42	0.76	0.68	0.17	0.07	2.16	1.61	2.08	1.19	0.21	0.12
	2	1.49	1.20	1.84	1.45	0.10	0.07	1.49	1.20	1.89	1.47	0.11	0.06	2.90	1.64	2.94	2.11	0.12	0.07
	3	2.03	1.61	2.32	1.74	0.12	0.07	2.03	1.61	2.39	1.80	0.14	0.10	[illegible]	1.13	3.63	2.69	0.15	0.11
LONGITUDINAL ACCELERATION (FT/SEC^2)	1	0.39	0.38	0.68	0.63	0.17	0.15	0.39	0.38	0.76	0.61	0.19	0.18	2.44	1.93	2.32	1.47	0.27	0.17
	2	0.87	0.72	1.19	0.99	0.09	0.07	0.87	0.72	1.22	0.97	0.10	0.05	1.94	1.40	2.05	1.40	0.12	0.07
	3	1.16	0.94	1.42	1.11	0.10	0.07	1.16	0.94	1.47	0.13	0.11	[illegible]	2.35	[illegible]	2.36	1.67	0.13	0.05

TABLE 6

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 60°, $H^{1/3}$ = 5 FEET

SS-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LOADED)
CRANE AT MIDSHIP
BOOM LENGTH = 120'
BOOM ELEVATION = 60°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTIONS SLEW ANGLE = 0°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 355.92 Y = 10.51 Z = 143.72						TIP MOTIONS SLEW ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 143.72						RELATIVE MOTION SLEW ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 143.72					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.39	0.34	0.71	0.64	1.95	1.75	0.22	0.21	0.54	0.43	2.38	2.26	[illegible]	[illegible]	2.59	2.25	4.52	2.56
	2	1.85	1.36	3.34	1.95	3.70	2.55	1.10	0.97	7.47	6.87	9.59	8.88	3.35	2.02	9.33	6.31	11.60	7.97
	3	2.52	1.81	5.68	2.45	6.31	3.04	1.44	1.25	17.36	17.00	21.19	20.82	4.30	2.26	19.79	15.53	23.69	19.33
VERTICAL VELOCITY (FT/SEC)	1	0.34	0.30	0.63	0.57	1.99	1.69	0.19	0.18	0.58	0.41	2.28	2.19	[illegible]	[illegible]	2.79	2.51	4.85	3.20
	2	1.01	0.76	1.92	1.19	2.35	1.73	0.57	0.50	4.16	3.80	5.51	5.10	2.12	1.57	5.37	3.63	6.32	4.56
	3	1.36	1.00	3.28	1.44	3.66	1.95	0.77	0.66	9.58	9.35	11.76	[illegible]	2.58	1.67	10.99	8.61	13.30	10.70
VERTICAL ACCELERATION (FT/SEC²)	1	0.31	0.27	0.59	0.52	1.89	1.68	0.17	0.16	0.55	0.41	2.28	2.21	2.54	2.43	3.30	3.03	5.94	4.55
	2	0.59	0.46	1.16	[illegible]	1.66	1.32	0.32	0.28	2.35	2.12	2.33	3.07	[illegible]	1.36	3.32	2.32	4.62	2.95
	3	0.78	0.58	[illegible]	0.89	2.27	1.41	0.43	0.37	5.29	5.16	6.61	6.47	[illegible]	1.41	5.24	4.98	7.77	6.09
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.01	0.76	2.56	2.48	0.00	0.00	0.93	0.79	2.51	2.46	0.00	0.00	2.45	1.68	5.00	3.97
	2	0.00	0.00	17.73	16.15	22.03	19.87	0.00	0.00	17.48	16.00	21.97	19.81	0.00	0.00	18.67	16.21	23.81	20.23
	3	0.00	0.00	43.62	40.03	52.48	47.48	0.00	0.00	43.17	[illegible]	52.34	47.35	0.00	0.00	44.85	40.43	54.81	48.70
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.90	0.62	2.47	2.36	0.00	0.00	0.93	0.66	2.42	2.35	0.00	0.00	2.65	1.92	5.58	4.43
	2	0.00	0.00	9.84	[illegible]	12.30	11.21	0.00	0.00	9.69	8.93	12.27	11.17	0.00	0.00	10.44	9.00	13.49	11.41
	3	0.00	0.00	24.03	22.07	28.94	26.23	0.00	0.00	23.78	21.85	28.87	26.16	0.00	0.00	24.74	22.27	30.32	26.90
TRANSVERSE ACCELERATION (FT/SEC²)	1	[illegible]	0.00	[illegible]	0.55	2.59	2.42	0.00	0.00	0.81	0.59	2.51	2.42	0.00	0.00	3.20	2.43	7.18	5.52
	2	0.00	0.00	[illegible]	5.05	6.99	6.43	0.00	0.00	5.42	5.01	5.97	6.41	0.00	0.00	5.97	5.08	8.06	6.72
	3	0.00	0.00	13.25	12.18	16.02	14.55	0.00	0.00	13.11	12.06	15.97	14.59	0.00	0.00	13.71	12.30	16.97	14.99
LONGITUDINAL DISPLACEMENT (FEET)	1	0.46	0.44	0.93	0.75	0.12	0.09	0.45	0.44	1.80	0.73	0.15	0.06	2.06	[illegible]	[illegible]	1.18	0.18	0.09
	2	2.53	1.97	2.77	2.14	0.10	0.07	2.52	1.97	3.16	2.20	0.14	0.09	[illegible]	2.24	4.53	1.40	0.15	0.09
	3	3.48	2.68	[illegible]	[illegible]	0.12	0.07	3.48	2.68	4.03	2.85	0.21	0.13	[illegible]	2.57	5.88	1.71	0.21	0.17
LONGITUDINAL VELOCITY (FT/SEC)	1	0.40	0.39	0.84	[illegible]	0.14	0.10	0.40	0.39	2.23	0.63	0.16	0.06	[illegible]	1.69	[illegible]	1.36	0.20	0.12
	2	1.40	1.12	1.70	1.15	0.09	0.06	1.40	1.12	2.07	1.37	0.11	[illegible]	[illegible]	[illegible]	2.93	1.01	0.12	0.07
	3	1.92	1.50	2.12	1.63	0.09	0.06	1.92	1.50	2.49	1.69	0.14	0.13	[illegible]	[illegible]	[illegible]	1.14	0.15	0.11
LONGITUDINAL ACCELERATION (FT/SEC²)	1	[illegible]	0.35	0.96	0.59	[illegible]	0.12	[illegible]	0.35	3.33	0.57	0.18	0.07	[illegible]	2.01	2.28	1.68	0.27	0.17
	2	0.82	0.67	1.13	[illegible]	[illegible]	0.05	0.82	0.67	1.69	1.69	0.10	0.05	1.93	1.19	[illegible]	0.87	0.12	0.07
	3	1.09	0.87	[illegible]	[illegible]	[illegible]	0.05	1.09	0.87	1.95	1.66	0.11	0.07	[illegible]	1.31	[illegible]	0.92	0.13	0.08

TABLE 7

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 75°, $H^{1/3}$ = 5 FEET

CS-S-738 CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 120'
BOOM ELEVATION = 75°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 326.98 Y = -18.43 Z = 155.71						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 155.71						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 155.71					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.31	0.26	0.61	0.45	2.02	1.96	0.22	0.21	0.64	0.43	2.38	2.26	2.03	1.93	2.59	2.25	4.52	2.56
	2	1.51	1.13	3.81	2.93	4.69	4.19	1.10	0.97	7.47	6.87	9.58	8.88	3.35	2.02	9.33	6.31	11.60	7.97
	3	2.04	1.48	7.63	6.83	8.92	8.62	1.45	1.25	17.38	17.00	21.19	20.82	4.30	2.26	19.79	15.53	23.69	19.33
VERTICAL VELOCITY (FT/SEC)	1	0.27	0.24	0.55	0.43	1.95	1.90	0.19	0.18	0.58	0.41	2.28	2.19	2.17	2.07	2.79	2.51	4.85	3.20
	2	0.81	0.61	2.15	1.61	2.86	2.58	0.57	0.50	4.16	3.80	5.51	5.10	2.12	1.57	5.37	3.63	6.92	4.56
	3	1.10	0.81	4.22	3.75	[illegible].06	4.88	0.77	0.66	9.58	9.36	11.76	11.54	2.58	1.67	10.99	8.61	13.30	10.70
VERTICAL ACCELERATION (FT/SEC²)	1	0.25	0.22	0.52	0.42	1.35	1.91	0.17	0.16	0.55	0.41	2.28	2.21	2.54	2.43	3.30	3.03	5.94	4.55
	2	0.46	0.36	1.25	0.91	1.91	1.76	0.32	0.28	2.35	2.12	3.33	3.07	1.60	1.38	3.32	2.32	4.62	2.95
	3	0.62	0.46	2.36	2.08	2.99	2.88	0.43	0.37	5.29	5.16	6.61	6.47	1.80	1.41	6.24	4.88	7.77	6.09
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.04	0.84	2.67	2.60	0.00	0.00	1.00	0.86	2.64	2.59	0.00	0.00	2.51	1.71	5.12	4.07
	2	0.00	0.00	19.01	17.47	23.70	21.54	0.00	0.00	18.86	17.39	23.67	21.51	0.00	0.00	20.05	17.59	25.50	21.93
	3	0.00	0.00	46.86	43.29	56.55	51.55	0.00	0.00	46.61	43.07	56.47	51.47	0.00	0.00	48.29	43.87	58.93	52.82
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.93	0.70	2.57	2.48	0.00	0.00	0.89	0.72	2.54	2.47	0.00	0.00	2.69	1.94	5.69	4.52
	2	0.00	0.00	10.55	9.74	13.23	12.14	0.00	0.00	10.46	9.70	13.21	12.12	0.00	0.00	11.20	9.77	14.42	12.35
	3	0.00	0.00	25.81	23.86	31.18	28.47	0.00	0.00	25.[illegible]	23.47	31.14	28.43	0.00	0.00	26.63	24.17	32.59	29.17
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	0.91	0.63	2.68	2.54	0.00	0.00	0.86	0.65	2.64	2.54	0.00	0.00	3.24	2.45	7.29	5.60
	2	0.00	0.00	5.90	5.46	7.51	6.95	0.00	0.00	5.95	5.44	7.50	6.94	[illegible]	0.00	6.40	5.51	8.57	7.23
	3	0.00	0.00	14.24	13.17	17.25	15.78	0.00	0.00	14.16	13.10	17.23	15.76	0.00	0.00	14.75	13.34	18.21	16.24
LONGITUDINAL DISPLACEMENT (FEET)	1	0.49	0.47	1.12	0.80	0.13	0.08	0.49	0.47	1.85	0.79	0.16	0.07	2.08	1.53	2.06	1.20	0.18	0.09
	2	2.68	2.10	3.00	2.32	0.11	0.07	2.68	2.10	3.33	2.35	0.14	0.10	4.84	2.35	4.69	1.55	0.15	0.10
	3	3.68	2.87	3.88	2.95	0.14	0.11	3.68	2.37	4.24	3.03	0.21	0.18	6.42	3.03	6.09	1.90	0.27	0.17
LONGITUDINAL VELOCITY (FT/SEC)	1	0.44	0.42	1.13	0.69	0.14	0.09	0.44	0.42	2.26	0.68	0.17	0.07	2.16	1.69	2.08	1.37	0.21	0.12
	2	1.49	1.20	1.87	1.45	0.09	0.06	1.49	1.20	2.17	1.47	0.11	0.06	2.90	1.56	2.94	1.09	0.12	0.07
	3	2.03	1.61	2.30	1.77	0.10	0.07	2.03	1.61	2.61	1.80	0.14	[illegible]	3.72	1.68	3.63	1.25	0.15	0.11
LONGITUDINAL ACCELERATION (FT/SEC²)	1	0.39	0.38	1.38	0.62	0.15	0.10	0.39	0.38	3.35	0.61	0.19	0.08	2.44	2.01	2.32	1.69	0.27	0.18
	2	0.87	0.72	1.28	0.97	0.08	0.05	0.87	0.72	1.75	5.44	0.10	0.05	1.98	1.21	2.05	0.91	0.12	0.07
	3	1.16	0.94	1.48	1.12	0.09	0.06	1.16	0.94	1.92	1.13	0.11	0.07	2.35	1.34	2.36	0.97	0.13	0.08

TABLE 8

BOOM TIP MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLES OF 45, 60, AND 75°, AND $H^{1/3}$ = 5 FEET

CS-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 120'

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. [illegible] MOSKOWITZ
2. BRETSCHNEIDER (SINGLE PEAK)
3. [illegible] (TWO [illegible] PEAKS)

MOTIONS PREDICTED	SPECTRA TYPE	BOOM ELEVATION = 75°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 336.42 Y = -43.93 Z = 155.71						BOOM ELEVATION = 60°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 336.45 Y = -35.45 Z = [illegible]						BOOM ELEVATION = 45°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 354.45 Y = -28.16 Z = [illegible]					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	[illegible]	0.25	[illegible]	0.43	2.29	2.18	0.34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.34	[illegible]	0.55	2.14	2.05
DISPLACEMENT	2	1.39	1.06	6.53	5.67	8.12	7.45	1.63	1.20	5.80	4.75	6.96	[illegible]	1.20	[illegible]	3.80	2.70	4.73	4.27
(FEET)	3	1.66	1.39	14.72	14.03	17.55	17.21	2.20	1.58	12.00	11.67	14.58	14.33	1.12	[illegible]	4.49	2.63	5.49	4.84
VERTICAL	1	0.25	0.22	0.63	0.42	2.19	2.11	0.33	0.26	0.67	0.46	[illegible]	[illegible]	0.34	0.30	0.71	0.52	2.06	1.99
VELOCITY	2	0.74	0.57	3.65	3.12	4.71	4.32	0.87	0.65	3.26	[illegible]	4.07	[illegible]	[illegible]	0.61	2.29	1.56	3.14	2.96
(FT/SEC)	3	1.01	0.75	5.12	[illegible]	[illegible]	9.57	1.20	0.87	6.96	6.42	[illegible]	7.99	0.51	[illegible]	2.30	1.65	[illegible]	3.74
VERTICAL	1	0.22	0.20	0.59	0.42	2.20	2.13	0.27	0.24	0.63	0.46	2.13	[illegible]	[illegible]	0.27	0.65	0.50	2.07	2.00
ACCELERATION	2	0.43	0.33	[illegible]	1.74	2.89	2.66	0.51	0.39	1.88	1.45	[illegible]	2.34	[illegible]	[illegible]	1.45	0.95	2.31	2.14
(FT/SEC2)	3	0.57	0.43	4.50	4.25	5.53	5.39	0.68	0.50	3.87	3.54	4.07	4.54	[illegible]	0.54	1.80	1.02	2.65	2.38
TRANSVERSE	1	0.00	0.00	1.03	0.85	2.66	2.60	0.00	0.00	0.99	[illegible]	2.55	2.46	[illegible]	[illegible]	[illegible]	[illegible]	2.69	2.61
DISPLACEMENT	2	0.00	0.00	18.97	17.45	23.69	21.53	0.00	0.00	17.66	[illegible]	22.01	[illegible]	[illegible]	[illegible]	13.39	12.42	16.60	15.64
(FEET)	3	0.00	0.00	46.79	43.03	55.53	51.52	0.00	0.00	43.49	39.91	[illegible]	[illegible]	[illegible]	0.00	14.00	[illegible]	[illegible]	16.83
TRANSVERSE	1	0.00	[illegible]	0.93	0.70	2.56	2.48	0.00	0.00	0.68	0.63	[illegible]	[illegible]	[illegible]	[illegible]	0.96	0.65	[illegible]	2.46
VELOCITY	2	0.00	0.00	13.52	9.73	13.23	12.13	[illegible]	[illegible]	9.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.69	9.09
(FT/SEC)	3	[illegible]	0.00	[illegible]	23.93	31.17	28.46	0.00	[illegible]	23.95	[illegible]	28.92	[illegible]	[illegible]	0.00	[illegible]	[illegible]	10.57	10.02
TRANSVERSE	1	0.00	0.00	0.59	0.63	2.66	2.54	0.00	0.00	0.96	0.56	2.55	[illegible]	0.00	[illegible]	[illegible]	0.62	[illegible]	2.54
ACCELERATION	2	0.00	0.00	5.85	5.46	7.51	6.95	0.00	0.00	5.48	[illegible]	6.99	[illegible]	[illegible]	[illegible]	[illegible]	4.02	5.91	5.50
(FT/SEC2)	3	0.00	0.00	14.21	13.15	[illegible]	15.77	0.00	0.00	13.21	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	6.47	6.18
LONGITUDINAL	1	0.49	[illegible]	1.62	0.79	[illegible]	[illegible]	[illegible]	0.44	1.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.14	0.08
DISPLACEMENT	2	2.64	2.10	[illegible]	2.34	[illegible]	[illegible]	[illegible]	1.97	2.99	2.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.17	[illegible]
(FEET)	3	[illegible]	[illegible]	[illegible]	[illegible]	0.19	[illegible]	[illegible]	2.69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.16	0.11
LONGITUDINAL	1	0.44	0.42	[illegible]	0.65	[illegible]	[illegible]	0.40	0.39	[illegible]	0.63	[illegible]	[illegible]	0.44	[illegible]	[illegible]	0.69	[illegible]	[illegible]
VELOCITY	2	1.49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.40	1.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(FT/SEC)	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LONGITUDINAL	1	0.39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.62	[illegible]	[illegible]
ACCELERATION	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
(FT/SEC2)	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 9

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 45°, AND $H^{1/3}$ = 5 FEET

CS-S-739 CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 45°

SPECTRA
[illegible] WAVE HEIGHT = 5 FEET
1 [illegible]
[illegible]
[illegible]

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION, SIDE ANGLE = 0°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 535.01 y = 40.37 z = 124.65						TIP MOTION, SIDE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 436.37 y = -49.40 z = 124.65						RELATIVE MOTION, SIDE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 436.37 y = -49.40 z = 124.65					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.60	0.74	1.62	1.48	2.35	1.62	0.61	0.55	1.32	[illegible]	2.41	[illegible]	[illegible]	1.49	[illegible]	[illegible]	4.55	[illegible]
	2	3.67	2.96	[illegible]	[illegible]	7.65	5.53	2.43	2.19	[illegible]	[illegible]	[illegible]	[illegible]	5.09	4.04	11.55	[illegible]	10.95	7.23
	3	5.06	4.07	16.54	10.77	16.37	12.26	3.69	2.47	15.97	16.02	19.47	19.11	6.74	5.44	20.60	16.61	22.01	17.54
VERTICAL VELOCITY (FT/SEC)	1	0.71	0.66	1.40	1.26	2.27	1.55	0.54	0.49	1.15	0.91	2.32	[illegible]	2.43	2.64	3.26	2.33	4.90	2.47
	2	2.06	1.72	4.83	3.51	4.46	3.21	1.57	1.26	4.85	3.59	[illegible]	4.23	3.32	2.48	6.19	4.13	6.59	4.13
	3	2.81	2.30	9.22	6.12	9.13	6.62	2.15	1.67	10.62	8.81	[illegible]	[illegible]	3.93	3.19	11.52	[illegible]	12.39	[illegible]
VERTICAL ACCELERATION (FT/SEC²)	1	0.64	0.60	1.28	1.13	2.29	1.53	0.49	0.44	1.06	[illegible]	2.34	1.22	[illegible]	2.43	3.66	2.86	5.99	4.35
	2	1.23	1.06	2.93	2.23	2.78	1.97	0.93	0.77	2.64	2.02	3.14	[illegible]	2.14	[illegible]	3.92	2.57	4.47	2.20
	3	1.62	1.35	5.21	3.55	5.13	3.65	1.23	0.95	[illegible]	[illegible]	6.11	5.97	[illegible]	2.65	6.53	5.20	7.33	5.54
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.06	0.61	2.47	2.32	0.00	0.00	0.99	0.62	2.42	2.30	0.00	0.00	2.52	1.62	4.92	3.72
	2	0.00	0.00	16.13	14.29	19.47	17.32	0.00	0.00	15.85	14.12	19.42	[illegible]	[illegible]	0.00	17.09	14.93	21.27	17.61
	3	0.00	0.00	39.18	35.49	46.24	41.24	0.00	0.00	35.71	35.06	46.09	[illegible]	0.00	0.00	41.41	36.56	45.57	42.36
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.97	0.49	2.41	2.21	0.00	0.00	0.89	0.57	2.35	2.19	0.00	[illegible]	[illegible]	[illegible]	5.54	4.26
	2	0.00	0.00	8.96	7.96	10.89	9.79	0.00	0.00	8.60	[illegible]	10.85	[illegible]	0.00	0.00	9.57	8.35	12.10	9.95
	3	0.00	0.00	21.59	19.56	25.51	22.79	0.00	0.00	21.32	[illegible]	25.42	[illegible]	0.00	[illegible]	22.30	[illegible]	26.89	23.41
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	0.97	0.42	2.56	2.25	0.00	0.00	[illegible]	0.44	[illegible]	2.24	[illegible]	[illegible]	3.33	2.50	7.19	5.42
	2	0.00	0.00	5.02	4.46	6.21	5.65	0.00	0.00	4.93	4.41	6.18	[illegible]	0.00	0.00	5.52	4.81	7.33	5.92
	3	0.00	0.00	11.91	10.79	[illegible]	12.65	[illegible]	[illegible]	11.76	[illegible]	[illegible]	[illegible]	0.00	0.00	[illegible]	11.38	[illegible]	[illegible]
LONGITUDINAL DISPLACEMENT (FEET)	1	0.41	0.39	0.74	0.67	0.13	0.10	0.41	0.39	0.75	0.64	[illegible]	0.05	[illegible]	[illegible]	1.98	1.34	0.16	0.05
	2	2.30	1.75	2.19	1.67	0.12	0.07	2.30	1.75	[illegible]	1.96	[illegible]	0.04	4.46	1.50	[illegible]	1.36	0.14	[illegible]
	3	3.15	2.39	3.03	2.35	0.17	0.05	3.15	2.39	[illegible]	2.54	0.19	[illegible]	[illegible]	[illegible]	5.51	[illegible]	0.20	[illegible]
LONGITUDINAL VELOCITY (FT/SEC)	1	0.36	0.34	0.61	[illegible]	0.14	0.11	0.36	0.34	0.64	0.55	[illegible]	[illegible]	[illegible]	[illegible]	1.96	1.44	0.19	[illegible]
	2	1.26	0.99	1.47	1.16	0.09	[illegible]	1.26	0.99	[illegible]	1.21	0.10	[illegible]	[illegible]	1.24	[illegible]	1.06	0.11	[illegible]
	3	[illegible]	[illegible]	2.24	1.42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LONGITUDINAL ACCELERATION (FT/SEC²)	1	0.32	0.31	0.57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	0.59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3	0.98	[illegible]	1.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 10

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 60°, AND $H^{1/3}$ = 5 FEET

[illegible] 736 CONTAINER SHIP [illegible]
[illegible] DRAFT [illegible]
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 60°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION, SLEW ANGLE = 0°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 436.37 y = 15.52 z = 143.72						TIP MOTION, SLEW ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 436.37 y = -49.48 z = 143.72						RELATIVE MOTION, SLEW ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM x = 436.37 y = -49.46 z = 143.72					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.70	0.69	1.39	1.29	2.08	1.77	0.61	0.55	1.32	0.87	2.41	2.27	2.36	1.59	3.19	2.10	4.55	2.37
	2	3.44	2.76	5.55	3.66	4.34	2.85	2.83	2.19	8.51	6.52	8.90	6.20	5.09	4.04	10.55	7.25	10.95	7.23
	3	4.74	3.77	9.37	4.77	7.97	4.27	3.89	2.97	18.07	16.02	19.48	17.11	6.74	5.44	20.60	16.61	22.01	17.54
VERTICAL VELOCITY (FT/SEC)	1	0.65	0.61	1.71	1.12	2.02	1.71	0.54	0.49	1.15	0.91	2.22	2.20	2.43	2.04	3.26	2.33	4.30	2.37
	2	1.93	1.60	3.28	2.34	2.69	1.87	1.57	1.26	4.85	3.59	5.14	4.73	3.08	2.48	6.19	4.13	6.59	4.13
	3	2.63	2.12	5.29	2.88	4.55	2.56	2.15	1.67	10.02	8.01	10.83	10.61	3.93	3.19	11.53	9.20	12.39	9.71
VERTICAL ACCELERATION (FT/SEC²)	1	0.60	0.55	1.10	1.01	2.03	1.70	0.49	0.44	1.06	0.77	2.34	2.22	2.75	2.43	3.68	2.88	5.99	4.35
	2	1.15	0.98	2.05	1.57	1.85	1.38	0.93	0.77	2.84	2.02	3.14	2.87	2.14	1.74	3.92	2.57	4.47	2.70
	3	1.57	1.25	3.07	1.82	2.74	1.69	1.23	0.98	5.60	4.87	6.11	5.97	2.52	2.06	6.63	5.20	7.30	5.54
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.15	0.72	2.65	2.52	0.00	0.00	1.10	0.73	2.62	2.50	0.00	0.00	2.62	1.93	5.12	3.89
	2	0.00	0.00	18.76	16.45	22.16	20.00	0.00	0.00	18.06	16.33	22.11	19.35	0.00	0.00	19.27	17.12	23.95	20.30
	3	0.00	0.00	44.53	40.84	52.76	47.76	0.00	0.00	44.18	40.53	52.65	47.65	0.00	0.00	45.87	42.03	55.12	48.92
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	1.04	0.57	2.59	2.39	0.00	0.00	0.99	0.59	2.54	2.38	0.00	0.00	2.90	2.07	5.71	4.40
	2	0.00	0.00	10.14	9.16	12.38	11.28	0.00	0.00	10.03	9.10	12.35	11.25	0.00	0.00	10.79	9.59	13.58	11.44
	3	0.00	0.00	24.53	22.51	29.10	26.39	0.00	0.00	24.34	22.34	29.04	26.33	0.00	0.00	25.31	23.19	30.50	27.02
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	1.03	0.50	2.73	2.43	0.00	0.00	0.97	0.51	2.67	2.43	0.00	0.00	3.34	2.53	7.35	5.54
	2	0.00	0.00	5.68	5.13	7.05	6.48	0.00	0.00	5.61	5.10	7.03	6.46	0.00	0.00	6.19	5.47	8.13	6.73
	3	0.00	0.00	13.54	12.42	16.11	14.63	0.00	0.00	13.43	12.33	16.07	14.60	0.00	0.00	14.01	12.64	17.08	15.05
LONGITUDINAL DISPLACEMENT (FEET)	1	0.46	0.44	0.81	0.75	0.12	0.09	0.46	0.44	0.64	0.73	0.15	0.07	[illegible]	1.69	[illegible]	1.38	0.17	0.09
	2	2.53	1.97	2.14	2.13	0.10	0.07	2.53	1.97	2.47	2.20	0.11	0.09	4.75	1.50	4.57	1.47	0.14	0.09
	3	3.48	2.68	3.26	2.70	0.13	0.07	3.48	2.68	3.41	2.83	0.20	0.17	6.22	1.59	5.49	1.68	0.20	0.16
LONGITUDINAL VELOCITY (FT/SEC)	1	0.40	0.39	0.69	0.65	0.13	0.13	0.40	0.39	0.73	0.67	0.16	0.07	2.14	1.51	[illegible]	1.45	0.20	0.12
	2	1.40	1.12	1.58	1.35	0.09	0.06	1.40	1.12	1.67	1.36	0.11	0.06	2.82	1.24	2.82	1.14	0.12	0.07
	3	1.92	1.53	2.13	1.63	0.09	0.06	1.92	1.53	2.31	1.68	0.13	0.10	3.60	[illegible]	3.49	1.27	0.14	0.10
LONGITUDINAL ACCELERATION (FT/SEC²)	1	[illegible]	[illegible]	0.52	[illegible]	0.14	0.13	0.45	0.35	[illegible]	0.57	0.17	0.07	2.47	[illegible]	2.29	1.71	0.26	0.17
	2	[illegible]	[illegible]	1.12	[illegible]	[illegible]	[illegible]	[illegible]	0.67	1.74	0.90	0.16	[illegible]	[illegible]	1.14	1.97	[illegible]	0.12	0.07
	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.87	1.69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.12	0.08

TABLE 11

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 75°, AND $H^{1/3}$ = 5 FEET

CS-5-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 75°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION, SLUE ANGLE = 0°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 464.66 Y = -13.42 Z = 155.71						TIP MOTION, SLUE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 155.71						RELATIVE MOTION, SLUE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 155.71					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.69	0.63	1.27	1.09	2.04	1.98	0.61	0.55	1.32	0.87	2.41	2.27	2.36	1.88	3.18	2.10	4.55	2.32
	2	3.18	2.51	5.05	3.47	4.07	3.65	2.83	2.19	8.51	6.52	8.90	8.20	5.09	4.04	10.55	7.25	10.95	7.23
	3	4.37	3.42	8.45	6.44	7.27	6.99	3.89	2.97	18.07	16.02	19.48	19.11	6.74	5.44	20.60	16.61	22.01	17.54
VERTICAL VELOCITY (FT/SEC)	1	0.61	0.56	1.11	0.97	1.98	1.92	0.54	0.49	1.15	0.81	2.32	2.20	2.43	2.04	3.26	2.33	4.90	2.97
	2	1.78	1.45	2.98	2.06	2.55	2.32	1.57	1.26	4.85	3.59	5.14	4.73	3.08	2.48	6.19	4.13	6.59	4.13
	3	2.42	1.93	4.77	3.63	4.18	4.02	2.15	1.67	10.02	8.81	10.83	10.61	3.93	3.19	11.53	9.20	12.39	9.71
VERTICAL ACCELERATION (FT/SEC²)	1	0.55	0.51	1.01	0.89	2.00	1.92	0.49	0.44	1.06	0.77	2.34	2.22	2.75	2.43	3.68	2.88	5.99	4.35
	2	1.06	0.89	1.86	1.32	1.78	1.64	0.93	0.77	2.84	2.02	3.14	2.89	2.14	1.74	3.92	2.57	4.47	2.70
	3	1.39	1.13	2.77	2.11	2.54	2.44	1.23	0.98	5.60	4.87	6.11	5.97	2.52	2.06	6.63	5.20	7.30	5.54
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.20	0.79	2.78	2.64	0.00	0.00	1.17	0.86	2.76	2.63	0.00	0.00	2.68	1.97	5.24	3.99
	2	0.00	0.00	19.56	17.78	23.84	21.67	0.00	0.00	19.44	17.71	23.81	21.65	0.00	0.00	20.65	18.49	25.64	22.00
	3	0.00	0.00	47.82	44.15	56.84	51.84	0.00	0.00	47.62	43.97	56.78	51.78	0.00	0.00	49.31	45.46	59.24	53.05
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	1.08	0.64	2.69	2.50	0.00	0.00	1.05	0.65	2.67	2.50	0.00	0.00	2.85	2.10	5.82	4.49
	2	0.00	0.00	10.86	9.90	13.32	12.21	0.00	0.00	10.80	9.87	13.30	12.20	0.00	0.00	11.55	10.35	14.52	12.38
	3	0.00	0.00	26.34	24.33	31.35	28.63	0.00	0.00	26.23	24.23	31.32	28.60	0.00	0.00	27.20	25.08	32.76	29.29
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	1.06	0.65	2.83	2.55	0.00	0.00	1.03	0.57	2.80	2.54	0.00	0.00	3.41	2.55	7.46	5.62
	2	0.00	0.00	6.08	5.55	7.57	7.00	0.00	0.00	6.05	5.53	7.56	6.99	0.00	0.00	6.61	5.89	8.64	7.24
	3	0.00	0.00	14.53	13.42	17.35	15.87	0.00	0.00	14.47	13.37	17.33	15.85	0.00	0.00	15.07	13.88	18.32	16.30
LONGITUDINAL DISPLACEMENT (FEET)	1	0.49	0.47	0.87	0.80	0.13	0.09	0.49	0.47	0.91	0.79	0.16	0.07	2.08	1.70	2.06	1.40	0.18	0.10
	2	2.68	2.10	2.49	2.31	0.10	0.07	2.68	2.10	2.63	2.35	0.14	0.09	4.84	1.51	4.67	1.56	2.67	0.09
	3	3.68	2.87	3.47	2.94	0.13	0.10	3.68	2.87	3.65	3.02	0.20	0.17	6.42	1.61	6.06	1.79	0.21	0.16
LONGITUDINAL VELOCITY (FT/SEC)	1	0.44	0.42	0.74	0.69	0.13	0.09	0.44	0.42	0.78	0.68	0.17	0.07	2.16	1.81	2.07	1.48	0.21	0.12
	2	1.49	1.20	1.69	1.45	0.08	0.06	1.49	1.20	1.78	1.47	0.11	0.06	2.90	1.25	2.92	1.19	0.12	0.07
	3	2.03	1.61	2.34	1.77	0.09	0.07	2.03	1.61	2.47	1.80	0.13	0.13	3.72	1.29	3.61	1.22	0.14	0.10
LONGITUDINAL ACCELERATION (FT/SEC²)	1	0.39	0.38	0.66	0.62	0.15	0.10	0.39	0.38	0.70	0.62	0.19	0.08	2.44	2.09	2.31	1.73	0.27	0.18
	2	0.87	0.72	1.20	0.97	0.08	0.05	0.87	0.72	1.25	0.97	0.10	0.05	1.98	1.14	2.04	1.02	2.02	0.07
	3	1.16	0.94	1.62	1.12	0.03	0.06	1.16	0.94	1.71	1.13	0.11	0.07	2.35	1.15	2.35	1.05	2.15	0.08

TABLE 12

BOOM TIP MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLES OF 45, 60, AND 75°, AND $H^{1/3}$ = 5 FEET

CS-5-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	BOOM ELEVATION = 75°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 456.38 Y = -38.9? Z = 155.71						BOOM ELEVATION = 60°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 471.73 Y = -33.44 Z = 143.?2						BOOM ELEVATION = 45°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 484.91 Y = -23.16 Z = 124.?5					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.66	0.61	1.36	0.98	2.31	2.19	0.71	0.65	1.39	1.08	2.23	2.12	0.74	0.68	1.42	1.16	2.16	2.07
	2	3.08	2.42	7.60	5.52	7.44	6.79	3.26	2.59	6.84	4.82	6.29	5.69	3.43	2.75	6.29	4.32	5.32	4.77
	3	4.23	3.29	15.38	13.17	15.87	15.51	4.49	3.53	13.24	10.93	12.99	12.64	4.71	3.74	11.43	9.09	10.57	10.20
VERTICAL VELOCITY (FT/SEC)	1	0.59	0.54	1.19	0.89	2.22	2.12	0.62	0.57	1.21	0.93	2.15	2.06	0.66	0.61	1.24	1.03	2.09	2.00
	2	1.72	1.39	4.36	3.07	4.35	3.97	1.83	1.50	3.99	2.72	3.73	3.38	1.92	1.59	3.68	2.50	3.21	2.90
	3	2.34	1.85	6.55	7.25	8.85	8.64	2.49	1.99	7.39	6.64	7.26	7.07	2.62	2.12	6.41	5.06	5.94	5.74
VERTICAL ACCELERATION (FT/SEC²)	1	0.53	0.49	1.09	0.84	2.24	2.13	0.56	0.52	1.11	0.90	2.17	2.07	0.59	0.55	1.12	0.95	2.11	2.01
	2	1.02	0.86	2.60	1.77	2.72	2.48	1.09	0.92	2.41	1.67	2.39	2.18	1.15	0.98	2.26	1.54	2.12	1.93
	3	1.35	1.09	4.81	4.02	5.04	4.90	1.43	1.17	4.19	3.38	4.18	4.05	1.51	1.24	3.67	[illegible]	3.47	3.34
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.19	0.79	2.77	2.64	0.00	0.00	1.14	0.72	2.65	2.52	0.00	0.00	1.04	0.61	2.45	2.32
	2	0.00	0.00	19.52	17.76	23.83	21.67	0.00	0.00	18.20	16.41	22.14	19.98	0.00	0.00	16.05	14.24	19.45	17.30
	3	0.00	0.00	47.76	44.09	56.82	51.82	0.00	0.00	26.65	40.75	52.73	47.73	0.00	0.00	39.04	35.36	46.19	41.19
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	1.07	0.64	2.68	2.50	0.00	0.00	1.02	0.58	2.56	2.39	0.00	0.00	0.94	0.49	2.39	2.20
	2	0.00	0.00	10.84	9.89	13.31	12.21	0.00	0.00	10.11	9.14	12.37	11.27	0.00	0.00	8.91	7.93	10.87	9.78
	3	0.00	0.00	26.31	24.30	31.34	28.62	0.00	0.00	14.68	22.46	29.04	26.37	0.00	0.00	21.51	19.49	25.46	22.7?
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	1.03	0.56	2.62	2.54	0.00	0.00	1.02	0.59	2.71	2.41	0.00	0.00	0.94	0.43	2.53	2.24
	2	0.00	0.00	6.07	5.54	7.57	7.00	0.00	0.00	5.66	5.17	7.04	6.47	0.00	0.00	5.00	4.45	6.20	5.64
	3	0.00	0.00	14.52	13.41	17.34	4.90	0.00	0.00	8.10	12.39	16.10	14.62	0.00	0.00	11.37	10.75	14.11	12.64
LONGITUDINAL DISPLACEMENT (FEET)	1	0.49	0.47	0.89	0.80	0.15	0.08	0.46	0.44	0.82	0.74	0.13	0.07	0.41	0.39	[illegible]	0.64	0.12	0.06
	2	2.69	2.10	2.59	2.34	0.13	0.08	2.53	1.97	2.40	2.17	0.12	0.09	2.30	1.75	2.12	1.92	0.19	0.07
	3	3.58	2.57	3.60	2.99	0.18	0.15	3.48	2.68	3.33	2.79	0.15	0.11	3.15	2.39	2.74	2.47	0.14	0.11
LONGITUDINAL VELOCITY (FT/SEC)	1	0.44	0.42	0.77	0.67	0.16	0.09	0.40	0.39	0.71	0.64	0.14	0.07	0.36	0.35	0.62	0.56	0.12	0.07
	2	1.47	1.20	1.75	1.46	0.10	0.06	1.40	1.12	1.62	1.36	0.09	0.05	1.26	0.97	1.43	1.19	0.08	0.05
	3	2.03	1.61	2.43	1.79	0.12	0.09	1.92	1.50	2.25	1.65	0.11	0.09	1.73	1.33	[illegible]	1.47	0.10	0.07
LONGITUDINAL ACCELERATION (FT/SEC²)	1	0.39	0.36	0.69	0.62	0.17	0.08	0.37	0.35	0.63	0.57	0.16	0.08	0.32	0.31	0.55	0.51	0.13	0.07
	2	0.87	0.72	1.24	0.97	0.09	0.05	0.82	0.67	1.14	0.90	0.05	0.05	0.74	0.49	1.01	0.79	0.07	0.04
	3	1.16	0.94	1.66	1.37	0.10	0.06	1.49	0.87	1.56	1.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 13

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 45°, AND $H^{1/3}$ = 3 FEET

CS-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 45°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 3 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 505.01 Y = 40.37 Z = 124.65						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 124.65						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 124.65					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	0.15	0.14	0.32	0.27	0.70	0.45	0.11	0.10	0.28	0.22	0.71	0.69	0.83	0.81	1.20	0.98	1.88	1.36
DISPLACEMENT	2	2.20	1.79	5.01	3.45	4.59	3.32	1.70	1.31	5.11	3.91	5.34	4.92	3.05	2.43	6.33	4.35	6.57	4.34
(FEET)	3	3.04	2.44	9.93	6.46	9.82	7.35	2.33	1.78	10.84	9.61	11.69	11.47	4.04	3.26	12.36	9.97	13.20	10.52
VERTICAL	1	0.14	0.14	0.34	0.28	0.79	0.49	0.11	0.10	0.29	0.23	0.80	0.75	1.13	1.05	1.54	1.32	2.56	2.05
VELOCITY	2	1.24	1.03	2.90	2.11	2.68	1.97	0.94	0.75	2.91	2.15	3.09	2.84	1.55	1.43	3.71	2.49	3.95	2.48
(FT/SEC)	3	1.69	1.38	5.53	3.67	5.48	4.09	1.29	1.00	6.01	5.29	6.50	6.36	2.36	1.91	6.92	5.52	7.44	5.83
VERTICAL	1	0.14	0.14	0.37	0.30	0.92	0.55	0.11	0.10	0.32	0.25	0.93	0.87	1.57	1.49	2.11	1.89	3.93	3.40
ACCELERATION	2	0.74	0.64	1.74	1.34	1.67	1.10	0.56	0.46	1.70	1.21	1.88	1.73	1.28	1.05	2.35	1.54	2.68	1.62
(FT/SEC²)	3	0.97	0.81	3.12	2.13	3.11	2.31	0.74	0.59	3.36	2.92	3.07	3.50	1.51	1.24	3.90	3.12	4.38	3.32
TRANSVERSE	1	0.00	0.00	0.29	0.10	0.81	0.69	0.00	0.00	0.27	0.11	0.78	0.69	0.00	0.00	1.10	0.83	2.29	1.60
DISPLACEMENT	2	0.00	0.00	9.68	8.57	11.64	10.39	0.00	0.00	9.51	8.47	11.64	10.35	0.00	0.00	10.25	8.94	12.76	10.56
(FEET)	3	0.00	0.00	23.51	21.29	27.74	24.74	0.00	0.00	23.22	21.03	27.65	24.66	0.00	0.00	24.24	21.94	29.14	25.41
TRANSVERSE	1	0.00	0.00	0.34	0.12	0.98	0.81	0.00	0.00	0.30	0.12	0.95	0.81	0.00	0.00	1.46	1.14	3.25	2.46
VELOCITY	2	0.00	0.00	5.38	4.78	6.53	5.86	0.00	0.00	5.26	4.72	6.51	5.85	0.00	0.00	5.74	5.03	7.26	5.97
(FT/SEC)	3	0.00	0.00	12.95	11.74	15.30	13.69	0.00	0.00	12.79	11.59	15.25	13.63	0.00	0.00	13.38	12.11	16.13	14.05
TRANSVERSE	1	0.00	0.00	0.43	0.15	1.28	1.00	0.00	0.00	0.40	0.15	1.23	1.01	0.00	0.00	2.11	1.66	5.09	3.69
ACCELERATION	2	0.00	0.00	3.01	2.68	3.73	3.39	0.00	0.00	2.96	2.65	3.71	3.37	0.00	0.00	3.31	2.88	4.40	3.55
(FT/SEC²)	3	0.00	0.00	7.15	6.47	8.47	7.59	0.00	0.00	7.06	6.40	8.45	7.56	0.00	0.00	7.43	6.71	9.06	7.84
LONGITUDINAL	1	0.07	0.07	0.14	0.13	0.05	0.05	0.07	0.07	0.15	0.13	0.05	0.07	0.79	0.70	0.72	0.56	0.08	0.05
DISPLACEMENT	2	1.38	1.05	1.31	1.12	0.07	0.04	1.36	1.05	1.33	1.19	0.08	0.05	2.65	0.90	2.54	0.87	0.08	0.05
(FEET)	3	1.89	1.43	1.82	1.41	0.10	0.05	1.89	1.43	1.85	1.53	0.12	0.10	3.54	0.97	3.31	0.93	0.12	0.10
LONGITUDINAL	1	0.07	0.07	0.15	0.13	0.06	0.06	0.07	0.07	0.16	0.13	0.07	0.07	1.01	0.93	0.93	[illegible]	0.11	[illegible]
VELOCITY	2	0.76	0.59	0.88	0.71	0.06	0.04	0.76	0.59	0.89	0.72	0.06	0.01	1.61	0.74	1.59	0.54	0.07	0.04
(FT/SEC)	3	1.04	0.80	1.23	0.94	0.07	0.04	1.04	0.80	1.24	0.90	[illegible]	0.06	2.05	[illegible]	1.97	0.63	0.04	0.05
LONGITUDINAL	1	0.07	0.07	0.17	0.14	0.08	0.06	0.07	0.07	0.17	0.15	[illegible]	0.03	1.35	1.21	1.30	1.09	0.18	0.14
ACCELERATION	2	0.44	0.36	0.62	0.40	0.05	0.04	0.44	0.36	0.63	0.46	0.05	0.03	1.11	[illegible]	1.11	0.56	0.07	0.04
(FT/SEC²)	3	0.59	0.46	0.85	0.54	0.05	0.03	0.59	0.46	0.66	0.56	[illegible]	0.04	[illegible]	0.69	1.29	0.55	0.03	0.05

TABLE 14

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 75°, AND $H^{1/3}$ = 3 FEET

CS-5-?38 CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 75°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 3 FEET
1. PIERSON-MOSKOWITZ
2. BRETSCHNEIDER (FULL PEAK)
3. BRETSCHNEIDER + SWELL (FULL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 414.66 Y = -13.42 Z = 155.71						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.49 Z = 155.71						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.49 Z = 155.71					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.13	[illegible]	0.25	[illegible]	0.61	0.59	0.11	0.10	[illegible]	0.22	0.71	[illegible]	[illegible]	[illegible]	1.20	[illegible]	1.98	1.36
	2	1.91	1.51	3.03	2.08	2.44	2.19	1.70	1.31	5.11	3.91	5.34	4.92	1.05	2.47	6.33	4.35	6.57	4.34
	3	2.42	2.05	5.07	3.87	4.36	4.20	2.33	1.78	10.84	9.61	11.69	11.47	4.04	1.26	12.36	9.97	13.20	10.52
VERTICAL VELOCITY (FT/SEC)	1	0.12	0.12	0.27	0.24	0.68	0.64	0.11	0.10	0.29	0.22	0.80	0.75	1.13	1.05	1.54	1.32	2.56	2.05
	2	1.07	0.87	1.79	1.24	1.53	1.39	0.94	0.75	2.91	2.15	3.09	2.84	1.85	1.49	3.71	2.48	3.95	2.48
	3	1.45	1.16	2.86	2.18	2.51	2.41	1.29	1.07	6.01	5.29	6.50	6.36	[illegible]	1.91	[illegible]	5.52	7.44	5.83
VERTICAL ACCELERATION (FT/SEC²)	1	0.13	0.12	0.29	0.26	0.78	0.73	0.11	0.10	0.32	0.25	0.93	0.87	1.57	1.49	2.11	1.89	3.93	3.40
	2	0.63	0.53	1.12	0.79	1.07	0.99	0.56	0.46	1.70	1.21	1.89	1.73	1.28	1.05	2.35	1.54	2.69	1.62
	3	0.64	0.68	1.56	1.26	1.53	1.45	0.74	0.59	3.36	2.92	3.67	[illegible]	[illegible]	[illegible]	3.93	3.12	4.30	3.32
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	0.32	0.14	.89	0.75	0.00	0.00	0.31	0.14	0.86	0.79	0.00	0.00	1.13	0.85	2.36	1.86
	2	0.00	0.00	11.73	10.67	14.30	13.00	0.00	0.00	11.67	10.63	14.29	12.93	0.00	0.00	12.39	11.10	15.35	13.20
	3	0.00	0.00	28.69	26.49	34.10	31.10	0.00	0.00	28.57	26.38	[illegible]	[illegible]	0.00	0.00	29.59	27.26	35.54	[illegible]
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.36	0.15	1.07	0.92	0.00	0.00	0.35	0.16	1.06	0.92	[illegible]	0.00	1.50	1.15	3.34	2.53
	2	0.00	0.00	6.52	5.94	7.99	7.33	0.00	0.00	6.48	5.92	[illegible]	[illegible]	[illegible]	0.00	6.93	6.23	8.71	7.43
	3	0.00	0.00	15.81	15.60	18.81	17.16	0.00	0.00	[illegible]	14.54	18.79	17.16	0.00	[illegible]	16.32	15.05	19.66	17.58
TRANSVERSE ACCELERATION (FT/SEC²)	1	[illegible]	0.00	0.46	0.13	1.39	1.14	0.00	0.00	0.45	[illegible]	1.37	1.15	[illegible]	[illegible]	2.15	1.67	5.21	3.75
	2	0.00	0.00	3.65	3.33	4.54	4.20	0.00	0.00	3.63	[illegible]	4.53	[illegible]	[illegible]	0.00	3.97	3.54	5.19	4.34
	3	0.00	0.00	[illegible]	8.05	10.41	9.57	[illegible]	0.00	8.69	8.02	10.40	[illegible]	[illegible]	[illegible]	9.64	[illegible]	10.99	[illegible]
LONGITUDINAL DISPLACEMENT (FEET)	1	0.09	[illegible]	0.16	0.15	0.05	0.04	0.09	0.09	0.17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.09	[illegible]
	2	1.61	1.26	1.59	1.39	0.05	0.04	1.61	1.20	1.58	1.41	[illegible]	[illegible]	2.30	[illegible]	[illegible]	0.94	0.09	[illegible]
	3	2.21	[illegible]	2.06	1.77	[illegible]	0.06	2.21	1.72	2.19	1.81	0.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LONGITUDINAL VELOCITY (FT/SEC)	1	[illegible]	[illegible]	[illegible]	0.16	0.06	[illegible]	[illegible]	0.08	[illegible]	0.16	0.06	0.03	[illegible]	[illegible]	0.95	0.74	0.12	0.09
	2	0.69	[illegible]	1.17	0.67	0.05	0.03	0.59	0.72	1.06	[illegible]	0.07	[illegible]	[illegible]	[illegible]	[illegible]	0.72	[illegible]	0.03
	3	1.22	[illegible]	[illegible]	[illegible]	[illegible]	0.04	1.22	0.97	[illegible]	1.03	0.08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LONGITUDINAL ACCELERATION (FT/SEC²)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.05	[illegible]	[illegible]	0.20	0.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.14
	2	[illegible]	0.43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.43	[illegible]	[illegible]	0.06	0.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 15

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 45°, AND $H^{1/3}$ = 6.5 FEET

C5-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 45°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 6.5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 505.01 Y = 40.37 Z = 124.65						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 124.65						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 124.65					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	1.57	1.44	3.43	3.13	3.64	2.65	1.18	1.06	2.87	[illegible]	4.30	3.65	3.68	2.83	5.36	3.27	6.68	1.01
DISPLACEMENT	2	4.78	3.68	10.86	7.47	9.94	7.20	3.68	2.85	11.97	8.47	11.57	10.67	6.62	5.25	13.72	9.43	14.23	9.40
(FEET)	3	6.58	5.29	21.51	14.01	21.28	15.94	5.05	3.66	23.49	20.83	25.32	24.84	8.76	7.07	26.78	21.59	28.61	22.90
VERTICAL	1	1.25	1.16	2.67	2.44	3.40	2.33	0.95	0.86	2.21	1.32	3.51	3.26	3.42	2.73	4.78	2.14	6.62	3.40
VELOCITY	2	2.60	2.24	6.28	4.56	5.80	4.17	2.05	1.63	6.30	4.66	6.69	6.15	4.01	3.23	8.05	5.36	8.56	5.37
(FT/SEC)	3	3.66	2.99	11.99	7.96	11.86	8.86	2.80	2.17	13.02	11.46	14.09	13.79	5.10	4.15	14.93	11.95	16.11	12.63
VERTICAL	1	1.05	0.97	2.19	1.98	3.19	2.17	0.80	0.72	1.81	1.16	3.27	3.08	3.51	2.96	4.77	3.46	7.22	4.76
ACCELERATION	2	1.60	1.38	3.77	2.90	3.62	2.57	1.21	1.00	3.69	2.62	4.08	3.75	2.78	2.27	5.09	3.34	5.81	3.62
(FT/SEC²)	3	2.11	1.76	6.77	4.61	6.74	5.01	1.60	1.28	7.26	6.33	7.95	7.76	3.26	2.68	9.62	6.76	9.49	7.20
TRANSVERSE	1	0.00	0.00	2.88	2.26	4.77	4.60	0.00	0.00	2.74	[illegible]	4.70	4.56	0.00	0.00	4.49	3.55	7.77	5.57
DISPLACEMENT	2	0.00	0.00	20.97	18.57	25.31	22.51	0.00	0.00	20.61	18.36	25.22	22.43	0.00	0.00	22.20	19.41	27.65	22.89
(FEET)	3	0.00	0.00	50.94	46.10	60.11	53.61	0.00	0.00	50.32	45.57	59.92	53.42	0.00	0.00	52.53	47.53	63.14	55.07
TRANSVERSE	1	0.00	0.00	2.05	1.46	3.90	3.71	0.00	0.00	1.93	1.48	3.83	3.67	0.00	0.00	3.94	3.03	7.43	5.50
VELOCITY	2	0.00	0.00	11.65	10.35	14.15	12.73	0.00	0.00	11.44	10.24	14.10	12.68	0.00	0.00	12.44	10.89	15.73	12.93
(FT/SEC)	3	0.00	0.00	28.06	25.63	33.16	29.63	0.00	0.00	27.72	25.12	33.05	29.53	0.00	0.00	28.99	26.23	34.96	30.43
TRANSVERSE	1	0.00	0.00	1.63	1.02	3.58	3.29	0.00	0.00	1.51	1.03	3.50	3.27	0.00	0.00	4.10	3.13	6.49	6.35
ACCELERATION	2	0.00	0.00	6.53	5.80	8.07	7.34	0.00	0.00	6.41	5.74	8.04	7.31	0.00	0.00	7.18	6.25	9.53	7.69
(FT/SEC²)	3	0.00	0.00	15.49	14.03	18.36	16.45	0.00	0.00	15.29	13.86	16.50	16.39	0.00	0.00	16.09	14.54	19.64	16.99
LONGITUDINAL	1	0.83	0.76	1.56	1.35	0.18	0.10	0.83	0.76	1.57	1.30	0.19	0.08	3.12	2.43	3.21	1.96	0.21	0.10
DISPLACEMENT	2	2.99	2.28	2.84	2.43	0.16	0.09	2.99	2.28	2.99	2.55	0.17	0.11	5.80	1.96	5.51	1.77	0.18	0.11
(FEET)	3	4.10	3.10	3.94	3.06	0.23	0.10	4.10	3.10	4.00	3.31	0.25	0.21	7.55	2.10	[illegible]	2.02	0.26	0.21
LONGITUDINAL	1	0.65	0.61	1.22	1.08	0.19	0.14	0.65	0.61	1.23	1.21	0.17	0.07	2.92	2.39	2.86	1.92	0.23	0.12
VELOCITY	2	1.64	1.29	1.91	1.53	0.12	0.08	1.64	1.29	1.94	1.57	0.13	0.07	3.49	1.61	3.45	1.38	0.14	0.08
(FT/SEC)	3	2.25	1.73	2.65	1.84	0.15	0.09	2.25	1.73	2.69	1.95	0.15	0.12	4.45	1.67	4.27	1.49	0.15	0.13
LONGITUDINAL	1	0.54	0.51	0.99	0.89	0.19	0.16	0.54	0.51	1.01	0.95	0.22	0.07	3.03	2.56	2.88	2.09	0.29	0.16
ACCELERATION	2	0.96	0.77	1.34	1.03	0.11	0.09	0.96	0.77	1.36	1.03	0.12	0.05	2.41	1.42	2.41	1.22	0.14	0.09
(FT/SEC²)	3	[illegible]	1.00	1.63	1.17	0.12	0.06	1.29	1.00	1.86	1.21	0.13	0.06	2.65	1.49	2.78	1.26	0.15	0.10

TABLE 16

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 120 FEET, BOOM ELEVATION ANGLE OF 75°, AND $H^{1/3}$ = 6.5 FEET

CS-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 120'
BOOM ELEVATION = 75°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 6.5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLEW ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 464.66 Y = -13.42 Z = 155.71						TIP MOTION SLEW ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 155.71						RELATIVE MOTION SLEW ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.46 Z = 155.71					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	1.34	1.22	2.69	2.27	3.21	3.07	1.18	1.06	2.87	1.58	4.00	3.65	3.68	2.83	5.36	3.27	6.88	3.03
	2	4.13	3.26	6.57	4.51	5.30	4.75	3.68	2.85	11.07	8.47	11.57	10.67	6.63	5.25	13.72	9.43	14.23	9.40
	3	5.68	4.44	10.98	8.38	9.45	9.09	5.05	3.86	23.49	20.83	25.32	24.84	8.76	7.07	26.78	21.59	26.61	22.80
VERTICAL VELOCITY (FT/SEC)	1	1.07	0.98	2.05	1.69	2.91	2.79	0.95	0.86	2.21	1.32	3.51	3.26	3.42	2.73	4.78	3.14	6.62	3.48
	2	2.31	1.88	3.88	2.68	3.31	3.01	2.05	1.63	6.30	4.65	6.66	6.15	4.01	3.23	8.05	5.36	8.56	5.37
	3	3.15	2.51	6.20	4.72	5.43	5.22	2.80	2.17	13.02	11.46	14.05	13.79	5.10	4.15	14.99	11.95	16.11	12.63
VERTICAL ACCELERATION (FT/SEC^2)	1	0.90	0.83	1.70	1.44	2.76	2.65	0.80	0.72	1.81	1.16	7.27	3.08	3.51	2.96	4.77	3.46	7.27	4.76
	2	1.37	1.16	2.42	1.71	2.31	2.14	1.21	1.00	3.69	2.62	4.08	3.75	2.78	2.27	5.09	3.34	5.81	3.52
	3	1.81	1.47	3.60	2.74	3.31	3.17	1.60	1.28	7.28	6.33	7.95	7.76	3.26	2.68	8.62	6.76	9.49	7.20
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	3.36	2.81	5.53	5.38	0.00	0.00	3.31	2.82	5.50	5.36	0.00	0.00	5.00	4.02	8.51	6.24
	2	0.00	0.00	25.42	23.11	30.99	28.18	0.00	0.00	25.27	23.03	30.95	28.14	0.00	0.00	26.85	24.04	33.33	28.60
	3	0.00	0.00	62.16	57.39	73.89	67.39	0.00	0.00	61.91	57.16	73.82	67.31	0.00	0.00	64.11	59.10	77.01	68.96
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	2.37	1.85	4.46	4.28	0.00	0.00	2.32	1.86	4.43	4.26	0.00	0.00	4.26	3.39	7.96	5.96
	2	0.00	0.00	14.12	12.87	17.31	15.88	0.00	0.00	14.03	12.83	17.29	15.86	0.00	0.00	15.02	13.46	18.87	16.09
	3	0.00	0.00	34.25	31.53	40.75	37.22	0.00	0.00	34.10	31.50	40.71	37.19	0.00	0.00	35.36	32.69	42.59	38.08
TRANSVERSE ACCELERATION (FT/SEC^2)	1	0.00	0.00	1.84	1.29	4.03	3.76	0.00	0.00	1.80	1.30	3.93	3.75	0.00	0.00	4.32	3.27	8.92	6.68
	2	0.00	0.00	7.91	16.33	9.84	9.10	0.00	0.00	7.56	7.19	9.83	9.09	0.00	0.00	8.60	7.66	11.24	9.41
	3	0.00	0.00	18.29	17.45	22.55	20.63	0.00	0.00	19.21	17.38	22.53	[illegible]	0.00	0.00	19.60	18.04	23.82	21.19
LONGITUDINAL DISPLACEMENT (FEET)	1	1.01	0.93	1.82	1.64	0.11	0.11	1.01	0.93	1.58	1.62	0.21	0.15	[illegible]	2.11	3.51	2.11	0.24	0.12
	2	3.48	2.74	1.50	3.01	0.13	0.09	3.48	2.74	3.41	3.35	0.18	0.12	6.29	[illegible]	6.07	2.03	0.19	0.12
	3	4.79	3.73	2.08	3.83	0.16	0.10	4.79	3.73	4.75	3.92	0.26	0.22	[illegible]	[illegible]	[illegible]	2.33	0.27	0.21
LONGITUDINAL VELOCITY (FT/SEC)	1	0.79	0.75	1.43	1.32	0.17	0.12	0.79	0.75	1.06	1.28	0.22	0.10	3.04	[illegible]	3.10	2.02	0.26	0.14
	2	1.93	1.56	1.01	1.69	0.11	0.07	1.93	1.56	2.31	1.90	0.14	0.59	[illegible]	1.55	3.80	1.55	0.16	0.09
	3	2.64	2.09	1.41	1.30	[illegible]	0.09	2.64	2.09	3.20	2.34	0.17	0.13	[illegible]	[illegible]	[illegible]	1.67	0.19	0.13
LONGITUDINAL ACCELERATION (FT/SEC^2)	1	0.65	[illegible]	1.16	1.07	0.15	0.12	0.65	0.63	0.75	1.06	0.23	0.13	2.11	[illegible]	[illegible]	2.15	0.31	0.20
	2	1.12	0.94	0.72	1.26	0.10	0.07	1.13	0.94	1.63	1.27	0.13	0.06	2.57	[illegible]	2.64	1.33	0.16	0.09
	3	1.51	[illegible]	[illegible]	1.46	0.11	0.07	1.51	1.24	[illegible]	1.47	0.14	[illegible]	[illegible]	[illegible]	[illegible]	1.37	[illegible]	[illegible]

TABLE 17

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLE OF 45°, AND $H^{1/3}$ = 5 FEET

C5-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 90'
BOOM ELEVATION = 45°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 359.56 Y = 14.15 Z = 103.44						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 103.44						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 103.44					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.40	0.35	0.75	0.66	1.99	1.73	0.22	0.21	0.64	0.43	2.38	2.26	2.03	1.93	2.59	2.25	4.52	2.56
	2	1.90	1.39	3.76	2.20	4.15	2.74	1.10	0.97	7.47	6.87	9.56	8.88	3.35	2.02	9.33	6.31	11.60	7.97
	3	2.58	1.85	6.94	3.25	7.50	3.88	1.45	1.25	17.38	17.00	21.19	20.82	4.30	2.26	19.79	15.53	23.69	19.33
VERTICAL VELOCITY (FT/SEC)	1	0.35	0.31	0.67	0.59	1.92	1.66	0.19	0.18	0.58	0.41	2.28	2.19	2.17	2.07	2.79	2.51	4.85	3.20
	2	1.03	0.78	2.15	1.34	2.59	1.91	0.57	0.50	4.16	3.60	5.51	5.10	2.12	1.57	5.37	3.63	6.92	4.56
	3	1.41	1.03	3.86	1.88	4.29	2.36	0.77	0.66	9.58	9.36	11.76	11.54	2.58	1.67	10.99	8.61	13.30	10.70
VERTICAL ACCELERATION (FT/SEC²)	1	0.32	0.28	0.62	0.54	1.93	1.65	0.17	0.16	0.55	0.41	2.28	2.21	2.54	2.43	3.30	3.03	5.94	4.55
	2	0.60	0.47	1.29	0.96	1.78	1.35	0.32	0.28	2.35	2.12	3.33	3.07	1.60	1.38	3.32	2.32	4.62	2.95
	3	0.80	0.60	2.18	1.12	2.59	1.58	0.43	0.37	5.29	5.16	6.61	6.47	1.83	1.41	6.24	4.88	7.77	6.09
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	0.78	0.53	2.13	2.05	0.00	0.00	0.70	0.56	2.07	2.03	0.00	0.00	2.26	1.60	4.59	3.62
	2	0.00	0.00	13.09	11.50	16.32	14.18	0.00	0.00	12.82	11.35	16.25	14.12	0.00	0.00	14.04	11.57	18.15	14.54
	3	0.00	0.00	32.09	28.49	38.62	33.54	0.00	0.00	31.61	28.07	38.48	33.49	0.00	0.00	83.31	28.88	40.97	34.84
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.70	0.43	2.07	1.97	0.00	0.00	0.61	0.46	2.01	1.95	0.00	0.00	2.48	1.86	5.21	4.14
	2	0.00	0.00	7.26	6.42	9.13	8.04	0.00	0.00	7.10	6.34	9.38	8.01	0.00	0.00	7.87	6.44	10.37	8.27
	3	0.00	0.00	17.67	15.71	21.31	18.61	0.00	0.00	17.41	15.46	21.22	18.53	0.00	0.00	18.38	15.91	22.71	19.29
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	0.70	0.37	2.18	2.03	0.00	0.00	0.62	0.41	2.10	2.02	0.00	0.00	3.06	2.39	6.84	5.28
	2	0.00	0.00	4.06	3.60	5.21	4.66	0.00	0.00	3.97	3.56	5.18	4.64	0.00	0.00	4.56	3.68	6.38	5.03
	3	0.00	0.00	9.75	8.67	11.80	10.34	0.00	0.00	9.60	8.54	11.75	10.29	0.00	0.00	10.21	[illegible]	12.81	10.82
LONGITUDINAL DISPLACEMENT (FEET)	1	0.35	0.33	0.80	0.55	0.10	0.07	0.35	0.33	1.65	0.53	0.13	0.04	1.96	1.53	1.83	1.15	0.15	0.07
	2	2.04	1.53	2.24	1.61	0.09	0.05	2.04	1.53	2.61	1.72	0.13	0.09	4.20	1.95	3.97	0.96	0.14	0.09
	3	2.79	2.07	2.92	2.05	0.12	0.06	2.79	2.07	3.33	2.26	0.20	0.17	5.54	2.41	5.18	1.11	0.21	0.17
LONGITUDINAL VELOCITY (FT/SEC)	1	0.30	0.29	0.82	0.48	0.10	0.08	0.30	0.29	2.13	0.46	0.14	0.04	[illegible]	1.69	1.89	1.33	0.18	[illegible]
	2	1.11	0.85	1.37	1.00	0.07	0.05	1.11	0.85	1.73	1.04	0.10	0.06	2.54	1.37	2.48	0.78	0.11	0.06
	3	1.53	1.15	1.71	1.22	0.80	0.05	1.53	1.15	2.07	1.32	0.13	0.10	3.22	[illegible]	[illegible]	0.84	[illegible]	0.10
LONGITUDINAL ACCELERATION (FT/SEC²)	1	0.27	0.26	1.03	0.43	0.11	0.09	0.27	0.26	3.27	0.42	0.15	0.05	[illegible]	2.00	2.17	1.66	0.24	0.17
	2	0.64	0.51	0.93	0.66	0.06	0.04	0.64	0.51	1.50	0.66	0.08	[illegible]	[illegible]	1.14	1.73	0.76	0.11	0.06
	3	0.86	0.66	1.09	0.77	0.07	0.04	0.86	0.66	1.62	0.81	0.10	0.06	2.08	[illegible]	[illegible]	0.78	0.12	0.08

TABLE 18

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLE OF 60°, AND $H^{1/3}$ = 5 FEET

CS-5-73C CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 90'
BOOM ELEVATION = 60°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 310.92 Y = 4.49 Z = 117.74						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 117.74						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 290.92 Y = -54.49 Z = 117.74					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	0.35	0.31	0.61	0.55	1.88	1.79	0.22	0.21	0.74	0.43	2.36	2.26	2.03	1.93	2.59	2.25	4.52	2.56
DISPLACEMENT	2	1.67	1.23	2.56	1.62	3.02	2.45	1.10	0.97	7.47	6.87	9.58	8.88	3.35	2.02	9.33	6.31	11.60	7.97
(FEET)	3	2.27	1.63	4.02	1.67	4.41	2.53	1.45	1.25	17.38	17.00	21.19	20.82	4.30	2.26	19.79	15.53	23.69	19.33
VERTICAL	1	0.31	0.27	0.55	0.50	1.82	1.73	0.19	0.18	0.58	0.41	2.28	2.19	2.17	2.07	2.79	2.51	4.85	3.20
VELOCITY	2	0.90	0.68	1.47	0.96	1.99	1.70	0.57	0.50	4.16	3.80	5.51	5.10	2.12	1.57	5.37	3.63	6.92	4.56
(FT/SEC)	3	1.24	0.89	2.25	0.99	2.66	1.73	0.77	0.66	9.58	9.36	11.76	11.54	2.58	1.67	10.99	5.61	13.30	10.70
VERTICAL	1	0.27	0.25	0.51	0.47	1.82	1.72	0.17	0.16	0.55	0.41	2.28	2.21	2.54	2.43	3.30	3.03	5.94	4.55
ACCELERATION	2	0.52	0.40	0.90	0.63	1.48	1.32	0.32	0.28	2.35	2.12	3.33	3.07	1.60	1.38	3.32	2.32	4.62	2.95
(FT/SEC^2)	3	0.70	0.52	1.30	0.64	1.77	1.34	0.43	0.37	5.29	5.16	6.61	6.47	1.80	1.41	6.24	4.88	7.77	6.09
TRANSVERSE	1	0.00	0.00	0.84	0.62	2.27	2.20	0.00	0.00	0.78	0.64	2.23	2.10	0.00	0.00	2.33	1.63	4.73	3.74
DISPLACEMENT	2	0.00	0.00	14.67	13.11	16.33	16.19	0.00	0.00	14.47	13.00	16.20	16.13	0.00	0.00	15.68	13.22	20.15	16.56
(FEET)	3	0.00	0.00	36.06	32.48	43.51	38.52	0.00	0.00	35.71	32.17	43.40	38.41	0.00	0.00	37.40	32.90	45.68	39.76
TRANSVERSE	1	0.00	0.00	0.75	0.50	2.20	2.10	0.00	0.00	0.70	0.53	2.15	2.09	0.00	0.00	2.54	1.88	5.34	4.24
VELOCITY	2	0.00	0.00	8.14	7.31	10.24	9.16	0.00	0.00	8.02	7.26	10.21	9.13	0.00	0.00	8.78	7.35	11.47	9.38
(FT/SEC)	3	0.00	0.00	19.66	17.91	24.00	21.29	0.00	0.00	19.67	17.74	23.94	21.23	0.00	0.00	20.64	18.17	25.41	21.99
TRANSVERSE	1	0.00	0.00	0.74	0.45	2.30	2.17	0.00	0.00	0.69	0.48	2.25	2.16	0.00	0.00	3.11	2.40	6.96	5.36
ACCELERATION	2	0.00	0.00	4.55	4.11	5.94	5.28	0.00	0.00	4.45	4.08	5.82	5.27	0.00	0.00	5.06	4.17	6.97	5.62
(FT/SEC^2)	3	0.00	0.00	10.55	9.88	13.29	11.62	0.00	0.00	10.35	9.79	13.25	11.79	0.00	0.00	11.45	10.05	14.28	12.30
LONGITUDINAL	1	0.39	0.37	0.72	0.62	0.13	0.07	0.39	0.37	1.70	0.60	0.14	0.05	2.00	1.53	1.69	1.15	0.16	0.09
DISPLACEMENT	2	2.21	1.66	2.36	1.80	0.08	0.04	2.21	1.68	2.80	1.89	0.13	0.09	4.38	[illegible]	4.17	1.11	0.14	0.09
(FEET)	3	3.04	2.28	3.08	2.30	0.10	0.07	3.04	2.29	3.58	2.46	0.20	0.17	5.76	2.66	5.43	1.31	0.21	0.17
LONGITUDINAL	1	0.34	0.33	0.64	0.53	0.10	0.05	0.34	0.33	2.16	[illegible]	[illegible]	0.05	2.39	[illegible]	1.54	1.34	0.19	0.11
VELOCITY	2	1.22	0.94	1.43	1.12	0.07	0.05	1.22	0.94	1.85	1.16	0.10	0.05	2.64	1.47	2.60	0.85	0.11	0.06
(FT/SEC)	3	1.67	1.27	1.86	1.37	0.07	0.05	1.67	1.27	[illegible]	1.45	0.11	[illegible]	[illegible]	[illegible]	3.03	1.93	0.14	0.10
LONGITUDINAL	1	0.31	0.29	0.63	0.45	0.11	0.09	0.31	0.29	3.79	0.47	0.37	[illegible]	[illegible]	[illegible]	[illegible]	1.67	0.25	0.17
ACCELERATION	2	0.73	0.57	0.93	0.75	[illegible]	0.74	0.70	0.57	1.55	0.76	0.29	0.04	1.53	1.15	1.63	0.73	0.11	0.07
(FT/SEC^2)	3	0.94	0.73	1.11	0.86	0.06	0.05	0.94	0.73	1.70	0.67	0.10	0.06	[illegible]	1.34	2.11	0.63	0.12	0.08

TABLE 19

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLE OF 75°, AND $H^{1/3}$ = 5 FEET

C5-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 90
BOOM ELEVATION = 75°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 319.21 Y = -26.20 Z = 126.73						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 293.92 Y = -54.49 Z = 126.73						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 293.92 Y = -54.49 Z = 126.73					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	0.29	0.26	0.62	0.42	2.10	2.02	0.22	0.21	0.64	0.43	2.36	2.26	[illegible]	1.93	2.59	2.25	4.52	2.56
DISPLACEMENT	2	1.42	1.08	4.57	3.72	5.71	5.13	1.10	0.97	7.47	6.87	7.58	6.66	3.35	2.02	9.33	6.31	11.60	7.97
(FEET)	3	1.90	1.41	9.71	8.99	11.54	11.21	1.45	1.25	17.38	17.00	21.19	20.82	4.30	2.26	19.79	15.53	23.69	19.33
VERTICAL	1	0.25	0.23	0.56	0.41	2.02	1.96	0.19	0.10	0.59	0.41	2.28	[illegible]	2.17	2.07	2.79	2.51	4.85	3.20
VELOCITY	2	0.76	0.50	2.56	2.05	3.40	3.06	0.57	0.50	4.16	3.80	5.51	5.10	2.12	1.57	5.37	3.63	6.92	4.56
(FT/SEC)	3	1.03	0.77	5.36	4.94	6.47	6.28	0.77	0.66	9.58	9.36	11.76	11.54	2.56	1.67	10.99	8.61	13.30	10.70
VERTICAL	1	0.23	0.21	0.52	0.40	2.02	1.97	[illegible]	0.16	0.55	0.41	2.28	2.21	2.54	2.43	3.30	3.03	5.94	4.55
ACCELERATION	2	0.43	0.34	1.48	1.14	2.20	2.01	0.32	0.20	2.35	2.12	3.33	3.07	1.60	1.36	3.32	2.32	4.62	2.95
(FT/SEC²)	3	0.58	0.44	2.98	2.73	3.74	3.62	0.43	0.37	5.29	5.16	6.61	6.47	1.80	1.41	6.24	4.88	7.72	6.09
TRANSVERSE	1	0.00	0.00	0.87	0.68	2.35	2.29	0.00	0.00	0.84	0.69	2.33	2.28	0.00	0.00	2.37	1.64	4.82	3.82
DISPLACEMENT	2	0.00	0.00	15.62	14.10	19.58	17.43	0.00	0.00	15.51	14.04	19.56	17.41	0.00	0.00	16.71	14.25	21.42	17.83
(FEET)	3	0.00	0.00	36.49	34.03	46.55	41.56	0.00	0.00	36.29	34.75	46.49	41.50	0.00	0.00	39.98	35.55	48.97	42.85
TRANSVERSE	1	0.00	0.00	0.77	0.56	2.27	2.19	0.00	0.00	0.74	0.55	2.24	2.16	0.00	0.00	2.58	1.89	5.42	4.30
VELOCITY	2	0.00	0.00	8.66	7.87	10.94	9.85	0.00	0.00	8.60	7.83	10.92	9.83	0.00	0.00	9.35	7.92	12.17	10.08
(FT/SEC)	3	0.00	0.00	21.20	19.25	25.68	22.97	0.00	0.00	21.09	19.16	25.64	22.94	0.00	0.00	22.06	19.59	27.11	23.69
TRANSVERSE	1	0.00	0.00	0.76	0.50	2.37	2.25	0.00	0.00	0.73	0.52	2.34	2.25	0.00	0.00	3.14	2.41	7.04	5.42
ACCELERATION	2	0.00	0.00	4.84	4.42	6.23	5.67	0.00	0.00	4.80	4.40	6.21	5.66	0.00	0.00	5.38	4.49	7.34	6.00
(FT/SEC²)	3	0.00	0.00	11.69	10.63	14.21	12.74	0.00	0.00	11.63	10.57	14.19	12.73	0.00	0.00	12.23	10.83	15.21	13.23
LONGITUDINAL	1	0.41	0.39	1.14	0.65	0.12	0.06	0.41	0.39	[illegible]	0.65	0.14	0.05	2.02	1.53	1.93	1.16	0.17	0.08
DISPLACEMENT	2	2.32	1.78	2.67	1.95	0.11	0.07	2.32	1.78	2.91	1.99	0.14	0.09	4.46	2.11	4.29	1.20	0.14	0.09
(FEET)	3	3.19	2.42	3.45	2.51	0.15	0.12	3.19	2.42	3.44	2.59	0.20	0.16	5.93	2.65	5.59	1.44	0.21	0.17
LONGITUDINAL	1	0.36	0.35	1.26	0.56	0.13	0.07	0.35	0.35	[illegible]	0.56	0.15	0.05	2.11	1.67	1.97	1.34	0.10	0.11
VELOCITY	2	1.26	1.20	1.67	1.21	0.05	0.05	1.28	1.20	1.73	1.23	0.10	0.06	[illegible]	1.45	2.68	0.90	0.11	0.07
(FT/SEC)	3	1.75	1.35	2.06	1.49	0.10	0.07	1.75	1.35	[illegible]	1.53	0.13	0.10	3.44	[illegible]	3.33	1.20	0.14	0.10
LONGITUDINAL	1	0.33	0.31	1.73	0.61	0.14	0.07	0.33	0.31	[illegible]	[illegible]	[illegible]	0.06	2.40	[illegible]	2.23	1.67	0.26	0.17
ACCELERATION	2	0.74	0.60	1.20	[illegible]	0.05	0.04	0.74	0.60	[illegible]	0.91	0.09	0.04	1.66	[illegible]	1.68	[illegible]	0.11	0.07
(FT/SEC²)	3	1.30	0.78	1.37	0.93	0.08	0.06	1.30	0.76	[illegible]	0.95	[illegible]	0.06	[illegible]	1.27	2.17	[illegible]	0.12	0.08

TABLE 20

BOOM TIP MOTIONS FOR CRANE AT MID-SHIP, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLES OF 45, 60, AND 75°, AND $H^{1/3}$ = 5 FEET

CS-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT MIDSHIP
BOOM LENGTH = 90'

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	BOOM ELEVATION = 75°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 310.93 Y = -46.20 Z = 126.73						BOOM ELEVATION = 60°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 326.28 Y = -39.85 Z = 117.75						BOOM ELEVATION = 45°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 339.46 Y = -34.39 Z = 103.44					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.27	0.24	0.69	0.43	2.30	2.19	0.31	0.28	0.73	0.45	2.24	2.14	0.34	0.30	0.76	0.49	2.19	2.10
	2	1.32	1.04	6.73	5.93	8.43	7.75	1.50	1.13	6.16	5.22	7.56	6.90	1.66	1.22	5.71	4.64	6.81	6.18
	3	1.77	1.35	15.29	14.67	18.35	17.99	2.03	1.48	13.70	12.89	16.18	15.82	2.25	1.61	12.34	11.38	14.32	13.97
VERTICAL VELOCITY (FT/SEC)	1	0.24	0.21	0.62	0.42	2.21	2.13	0.27	0.24	0.65	0.44	2.16	2.08	0.30	0.27	0.68	0.47	2.11	2.04
	2	0.70	0.55	3.76	3.27	4.88	4.48	0.80	0.61	3.46	2.87	4.40	4.02	0.89	0.67	3.21	2.55	4.00	3.64
	3	0.95	0.73	8.43	8.07	10.21	9.99	1.10	0.80	7.56	7.09	9.02	8.80	1.22	0.88	6.82	6.25	8.00	7.79
VERTICAL ACCELERATION (FT/SEC²)	1	0.21	0.19	0.58	0.42	2.22	2.14	0.24	0.22	0.61	0.44	2.16	2.09	0.27	0.24	0.63	0.46	2.12	2.05
	2	0.40	0.32	2.14	1.82	2.99	2.75	0.46	0.36	1.98	1.60	2.73	2.50	0.52	0.40	1.85	1.42	2.52	2.30
	3	0.54	0.41	4.67	4.45	5.76	5.62	0.62	0.46	4.20	3.91	5.12	4.98	0.69	0.51	3.79	3.45	4.57	4.43
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	0.86	0.68	2.34	2.29	0.00	0.00	0.82	0.62	2.26	2.19	0.00	0.00	0.75	0.54	2.11	2.04
	2	0.00	0.00	15.59	14.08	19.57	17.42	0.00	0.00	14.61	13.08	18.31	16.17	0.00	0.00	13.01	11.45	16.30	14.16
	3	0.00	0.00	38.43	34.87	46.54	41.54	0.00	0.00	35.96	32.39	43.47	38.48	0.00	0.00	31.95	28.37	38.58	33.60
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.76	0.56	2.26	2.19	0.00	0.00	0.74	0.51	2.18	2.10	0.00	0.00	0.68	0.44	2.05	1.96
	2	0.00	0.00	8.65	7.86	10.93	9.85	0.00	0.00	8.10	7.30	10.23	9.15	0.00	0.00	7.21	6.39	9.11	8.03
	3	0.00	0.00	21.17	19.23	25.67	22.96	0.00	0.00	19.80	17.86	23.98	21.28	0.00	0.00	17.59	15.64	21.28	18.58
TRANSVERSE ACCELERATION (FT/SEC²)	1	0.00	0.00	0.75	0.50	2.36	2.25	0.00	0.00	0.73	0.45	2.29	2.17	0.00	0.00	0.68	0.38	2.16	2.02
	2	0.00	0.00	4.83	4.41	6.22	5.67	0.00	0.00	4.53	4.10	5.83	5.28	0.00	0.00	4.03	3.59	5.20	4.66
	3	0.00	0.00	11.67	10.61	14.21	12.74	0.00	0.00	10.92	9.86	13.28	11.61	0.00	0.00	9.70	8.63	11.79	10.33
LONGITUDINAL DISPLACEMENT (FEET)	1	0.41	0.39	1.55	0.65	0.14	0.06	0.39	0.37	1.38	0.60	0.13	0.05	0.35	[illegible]	1.21	0.53	0.11	0.05
	2	2.32	1.78	2.85	1.98	0.13	0.09	2.21	1.68	2.67	1.56	0.19	0.08	2.04	1.53	2.47	1.68	0.11	0.07
	3	3.19	2.42	3.65	2.57	0.19	0.16	3.04	2.28	3.43	2.41	0.17	0.15	2.79	[illegible]	3.12	2.19	0.16	0.10
LONGITUDINAL VELOCITY (FT/SEC)	1	0.36	0.35	1.91	0.56	0.14	0.06	0.34	0.33	1.67	0.52	0.13	0.05	0.30	0.27	1.46	0.46	0.12	0.05
	2	1.26	1.00	1.85	1.22	0.10	0.06	1.22	0.94	1.71	1.15	0.09	0.05	1.11	0.85	1.54	1.03	0.08	0.05
	3	1.75	1.35	2.23	1.52	[illegible]	0.09	1.67	1.27	2.08	1.42	0.11	[illegible]	[illegible]	[illegible]	[illegible]	1.28	0.10	[illegible]
LONGITUDINAL ACCELERATION (FT/SEC²)	1	0.33	0.31	2.84	0.51	0.16	0.06	0.31	0.29	2.47	0.47	0.15	0.06	[illegible]	[illegible]	2.14	0.42	0.13	0.05
	2	0.74	0.60	1.49	0.81	0.09	0.04	0.71	0.57	1.34	0.75	0.09	0.04	0.54	0.51	[illegible]	0.67	0.07	0.03
	3	1.00	0.78	1.63	0.95	0.10	0.06	0.94	0.73	1.49	[illegible]	0.09	0.05	0.86	0.66	[illegible]	[illegible]	0.09	0.05

TABLE 21

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLE OF 45°, AND $H^{1/3}$ = 5 FEET

C5-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 90'
BOOM ELEVATION = 45°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 505.01 Y = 19.16 Z = 103.44						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 103.44						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 103.44					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.80	0.74	1.50	1.40	2.13	2.12	0.61	0.55	1.32	0.87	2.41	2.27	2.36	1.88	3.18	2.10	4.55	2.32
	2	3.67	2.98	6.15	4.09	4.81	5.55	2.83	2.19	8.51	6.52	8.90	8.20	5.09	4.04	10.55	7.25	10.95	7.23
	3	5.06	4.07	10.66	5.66	9.18	12.28	3.89	2.97	18.07	16.02	19.48	19.11	3.69	5.44	20.60	16.61	21.01	17.54
VERTICAL VELOCITY (FT/SEC)	1	0.71	0.66	1.30	1.21	2.06	2.05	0.54	0.49	1.15	0.81	2.32	2.20	2.43	2.04	3.26	2.33	4.90	2.97
	2	2.06	1.72	3.63	2.60	2.94	3.31	1.57	1.26	4.85	3.59	5.14	4.73	3.09	2.48	6.19	4.13	6.59	4.13
	3	2.81	2.30	6.01	3.38	5.21	6.87	2.15	1.67	10.02	8.81	10.83	10.61	3.92	3.19	11.53	9.20	12.39	9.71
VERTICAL ACCELERATION (FT/SEC^2)	1	0.64	0.60	1.18	1.09	2.08	2.06	0.49	0.44	1.06	0.77	2.34	2.22	2.75	2.49	3.68	2.89	5.99	4.3[illegible]
	2	1.23	1.06	2.26	1.74	1.98	2.14	0.93	0.77	2.84	2.02	3.14	2.89	2.14	1.74	3.92	2.57	4.47	2.70
	3	1.62	1.35	3.47	2.11	3.08	3.95	1.23	0.98	5.60	4.87	6.11	5.97	2.52	2.06	6.63	5.20	7.30	5.54
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	0.94	0.51	2.24	2.09	0.00	0.00	0.86	0.51	2.19	2.07	0.00	0.00	2.42	1.81	4.71	3.55
	2	0.00	0.00	13.68	11.85	16.46	14.30	0.00	0.00	13.40	11.68	16.39	14.25	0.00	0.00	14.65	12.51	18.29	14.61
	3	0.00	0.00	33.10	29.40	38.93	33.90	0.00	0.00	32.[illegible]	28.97	30.97	33.80	0.00	0.00	34.23	30.49	41.28	35.06
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.86	0.40	2.20	2.00	0.00	0.00	0.79	0.41	2.14	1.98	0.00	0.00	2.64	1.99	5.35	4.10
	2	0.00	0.00	7.60	6.60	9.21	8.12	0.00	0.00	7.44	6.51	9.17	8.09	0.00	0.00	8.23	7.04	10.47	8.30
	3	0.00	0.00	18.23	16.21	21.48	18.75	0.00	0.00	17.97	15.97	21.40	18.70	0.00	0.00	16.96	16.83	22.89	19.40
TRANSVERSE ACCELERATION (FT/SEC^2)	1	0.00	0.00	0.87	0.36	2.34	2.04	0.00	0.00	0.79	0.35	2.26	2.03	0.00	0.00	3.22	2.48	7.01	5.30
	2	0.00	0.00	4.26	3.70	5.27	4.71	0.00	0.00	4.17	3.65	5.24	4.69	0.00	0.00	4.79	4.07	6.45	5.03
	3	0.00	0.00	10.07	8.94	11.91	10.42	0.00	0.00	9.91	8.81	11.86	10.39	0.00	0.00	10.54	9.34	12.92	10.88
LONGITUDINAL DISPLACEMENT (FEET)	1	0.35	0.33	0.61	0.55	0.10	0.05	0.35	0.33	0.64	0.53	0.12	0.04	1.97	1.67	1.82	1.30	0.15	0.07
	2	2.04	1.53	1.83	1.61	0.09	0.07	2.04	1.53	1.94	1.71	0.12	0.09	4.20	1.56	3.85	1.29	0.13	0.08
	3	2.79	2.07	2.53	2.04	0.13	0.12	2.79	2.07	2.69	2.24	0.19	0.16	5.54	1.72	5.14	1.50	0.20	0.16
LONGITUDINAL VELOCITY (FT/SEC)	1	0.3.	0.29	0.52	0.48	0.10	0.05	0.30	0.29	0.55	0.46	0.13	0.04	2.06	1.79	1.89	1.41	0.18	0.10
	2	1.11	0.85	1.23	1.00	0.07	[illegible]	1.11	0.85	1.30	1.04	0.09	0.05	2.54	1.26	2.47	1.01	0.10	0.06
	3	1.53	1.15	1.70	1.22	0.09	0.07	1.53	1.15	1.81	1.31	0.12	0.09	3.22	1.32	3.06	1.09	0.13	0.10
LONGITUDINAL ACCELERATION (FT/SEC^2)	1	0.27	0.26	0.47	0.43	0.11	0.05	0.27	0.26	0.50	0.42	0.15	0.05	2.36	2.07	2.16	1.68	0.24	0.16
	2	0.64	0.51	0.86	0.66	0.06	0.03	0.64	0.51	0.91	0.68	0.08	0.04	1.77	1.13	1.74	0.91	0.10	0.06
	3	0.86	0.66	1.17	0.77	0.07	0.05	0.86	0.66	1.24	0.81	0.09	0.06	2.08	1.15	2.00	0.93	0.11	0.07

TABLE 22

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLE OF 60°, AND $H^{1/3}$ = 5 FEET

SS-S-738 CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 90'
BOOM ELEVATION = 60°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION SLUE ANGLE = 0° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 466.37 Y = .52 Z = 117.74						TIP MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 117.74						RELATIVE MOTION SLUE ANGLE = 90° TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 117.74					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	0.74	0.69	1.31	1.24	1.92	1.88	0.6[illegible]	0.55	1.37	0.87	2.41	2.27	2.36	1.88	3.18	2.10	4.55	2.32
DISPLACEMENT	2	3.44	2.76	4.19	3.28	2.65	2.57	2.83	2.19	9.51	6.67	8.92	9.20	5.09	4.04	10.55	7.25	10.95	7.23
(FEET)	3	4.74	3.77	5.53	4.10	3.30	3.06	3.89	2.97	17.06	16.02	19.45	19.11	6.74	5.44	20.60	16.61	22.01	17.54
VERTICAL	1	0.66	0.61	1.14	1.08	1.97	1.82	0.54	0.49	1.15	0.81	2.37	2.20	2.43	2.04	3.26	2.32	4.93	2.97
VELOCITY	2	1.93	1.60	2.55	2.08	1.83	1.78	1.57	1.26	4.85	3.59	5.14	4.73	3.09	2.48	6.19	4.13	6.59	4.13
(FT/SEC)	3	2.63	2.13	3.23	2.48	2.13	2.00	2.15	1.67	10.02	5.81	10.83	10.61	3.93	3.19	11.53	9.20	12.39	9.71
VERTICAL	1	0.60	0.55	1.03	0.99	1.88	1.81	0.49	0.44	1.26	0.77	2.34	2.22	2.75	2.43	3.58	2.88	5.99	4.35
ACCELERATION	2	1.15	0.98	1.66	1.41	1.42	1.38	0.93	0.7[illegible]	2.84	2.02	3.14	2.89	2.13	1.74	3.92	2.37	4.47	2.70
(FT/SEC²)	3	1.52	1.25	1.9[illegible]	1.59	1.54	1.47	1.23	0.98	5.60	4.85	1.11	5.97	2.52	2.06	6.63	5.20	7.30	5.54
TRANSVERSE	1	0.00	0.00	1.00	0.58	2.38	2.24	0.00	0.00	0.95	0.59	2.34	2.23	0.00	0.00	2.49	1.85	4.85	3.66
DISPLACEMENT	2	0.00	0.00	15.25	13.45	18.47	16.32	0.00	0.00	15.05	13.33	18.42	15.77	0.00	0.00	16.23	14.14	20.30	16.63
(FEET)	3	0.00	0.00	37.07	33.39	43.82	38.82	0.00	0.00	36.72	33.07	43.71	38.72	0.00	0.00	38.43	34.58	46.19	39.99
TRANSVERSE	1	0.00	0.00	0.91	0.46	2.33	2.14	0.00	0.00	0.86	0.47	2.26	2.12	0.00	0.00	2.70	2.02	5.48	4.21
VELOCITY	2	0.00	0.00	6.47	7.49	10.33	9.24	0.00	0.00	6.36	7.43	10.30	9.21	0.00	0.00	9.13	7.94	11.57	9.41
(FT/SEC)	3	0.00	0.00	20.42	18.43	24.17	21.46	0.00	0.00	20.73	16.23	24.11	21.40	0.00	0.00	21.21	19.09	25.59	22.10
TRANSVERSE	1	0.00	0.00	0.91	0.40	2.47	2.18	0.00	0.00	0.55	0.41	2.41	2.17	0.00	0.00	7.27	2.59	7.13	5.39
ACCELERATION	2	0.00	0.00	4.[illegible]5	4.23	5.90	5.34	0.00	0.00	4.66	4.17	5.85	5.32	0.00	0.00	5.25	4.57	[illegible]	5.63
(FT/SEC²)	3	0.00	0.00	11.27	10.15	13.39	11.92	0.00	0.00	11.15	10.06	13.35	11.89	[illegible]	0.00	11.78	10.53	14.39	12.35
LONGITUDINAL	1	0.39	0.37	0.66	0.62	0.09	0.07	0.39	0.37	[illegible]	0.63	0.13	0.09	2.09	1.68	[illegible]	1.33	0.16	0.08
DISPLACEMENT	2	2.21	1.69	1.95	1.91	0.08	0.06	2.21	1.68	2.17	1.89	0.13	0.09	4.38	1.53	4.14	1.33	0.14	0.09
(FEET)	3	3.33	2.28	2.77	2.31	0.09	0.08	3.04	2.28	2.95	2.44	0.19	0.16	5.79	1.54	5.39	1.53	0.23	0.16
LONGITUDINAL	1	0.34	0.33	0.57	0.53	0.10	[illegible]	0.34	0.33	0.61	0.52	0.14	0.09	2.09	1.70	1.35	1.43	0.19	0.11
VELOCITY	2	1.22	0.94	1.31	1.13	0.06	0.05	1.22	0.94	1.43	1.15	0.10	0.06	2.74	1.24	2.55	1.04	0.11	0.06
(FT/SEC)	3	1.67	1.27	1.99	1.37	0.07	0.05	1.67	1.27	1.93	1.44	0.12	0.09	3.76	1.23	3.21	1.10	0.14	0.10
LONGITUDINAL	1	0.31	0.29	0.51	0.49	0.12	0.07	0.31	0.29	0.56	0.47	0.16	0.05	2.37	0.09	2.09	1.69	0.25	0.17
ACCELERATION	2	0.73	0.57	0.92	0.76	0.05	0.04	0.71	0.57	1.09	0.76	0.07	0.04	1.93	1.13	1.93	0.93	0.11	0.06
(FT/SEC²)	3	0.94	0.73	1.26	0.97	0.08	0.05	0.94	0.73	1.27	0.94	0.10	0.06	2.15	1.15	2.10	0.99	0.12	0.08

TABLE 23

BOOM TIP AND RELATIVE MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLE OF 75°, AND $H^{1/3}$ = 5 FEET

C5-S-73B CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 90'
BOOM ELEVATION = 75°

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	TIP MOTION, SLUE ANGLE = 0°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 464.66 Y = -21.19 Z = 126.73						TIP MOTION, SLUE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 126.73						RELATIVE MOTION, SLUE ANGLE = 90°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 436.37 Y = -49.48 Z = 126.73					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL	1	.69	0.63	1.31	1.07	2.13	2.04	0.61	0.55	1.32	0.67	2.41	2.27	2.36	1.82	3.18	2.10	4.55	2.32
DISPLACEMENT	2	3.28	2.51	5.83	4.00	5.06	4.53	2.83	2.19	8.51	6.52	6.90	8.20	5.09	4.04	10.55	7.25	10.95	7.23
(FEET)	3	4.37	3.42	10.56	8.41	9.86	9.54	3.89	2.97	18.07	16.02	19.45	19.11	6.74	5.44	20.60	16.61	22.01	17.54
VERTICAL	1	.61	0.56	1.14	0.95	2.06	1.98	0.54	0.49	1.15	0.81	2.32	2.20	2.41	2.01	3.25	2.33	4.30	2.97
VELOCITY	2	1.78	1.45	3.40	2.30	3.07	2.77	1.57	1.26	4.85	3.59	5.14	4.73	3.06	2.46	6.19	4.13	6.59	4.13
(FT/SEC)	3	2.42	1.93	5.92	4.69	5.57	5.38	2.15	1.67	10.02	8.81	10.83	10.61	3.93	3.19	11.53	9.20	12.39	9.71
VERTICAL	1	0.55	0.51	1.04	0.88	2.07	1.98	0.49	0.44	1.06	0.77	2.34	2.22	2.75	2.43	3.68	2.58	5.99	4.35
ACCELERATION	2	1.06	0.89	2.09	1.41	2.04	1.97	.93	0.77	2.54	2.02	3.14	2.89	2.14	1.74	3.92	2.57	4.47	2.79
(FT/SEC²)	3	1.39	1.13	3.36	2.65	3.27	3.15	1.23	0.95	5.60	4.07	6.11	6.11	2.52	2.05	6.63	5.22	7.30	5.54
TRANSVERSE	1	0.0	0.0	1.03	0.63	2.46	2.33	0.0	0.0	1.00	0.64	2.44	2.32	0.0	0.0	2.53	1.88	4.94	3.74
DISPLACEMENT	2	0.0	0.0	16.21	14.43	19.72	17.57	0.0	0.0	16.09	14.37	19.70	17.54	0.0	0.0	17.32	15.17	21.56	17.99
(FEET)	3	0.0	0.0	39.50	35.63	46.86	41.87	0.0	0.0	39.30	35.65	46.60	41.81	0.0	0.0	41.30	37.16	49.28	43.07
TRANSVERSE	1	0.0	0.0	0.93	0.50	2.40	2.22	0.0	0.0	0.90	0.51	2.37	2.21	0.0	0.0	2.73	2.04	5.60	4.27
VELOCITY	2	0.0	0.0	9.00	8.04	11.03	9.93	0.0	0.0	8.93	8.01	11.01	9.92	0.0	0.0	9.70	8.54	12.26	10.11
(FT/SEC)	3	0.0	0.0	21.76	19.75	25.85	23.14	0.0	0.0	21.65	19.65	25.82	23.11	0.0	0.0	22.63	20.52	27.28	23.83
TRANSVERSE	1	0.0	0.0	0.94	0.44	2.53	2.26	0.0	0.0	0.90	0.44	2.50	2.26	0.0	0.0	3.30	2.51	7.21	5.44
ACCELERATION	2	0.0	0.0	5.04	4.51	6.29	5.72	0.0	0.0	5.00	4.49	6.27	5.71	0.0	0.0	5.60	4.88	7.42	6.00
(FT/SEC²)	3	0.0	0.0	12.01	10.92	14.31	12.64	0.0	0.0	11.95	10.84	14.29	12.82	0.0	0.0	12.56	11.36	15.32	13.29
LONGITUDINAL	1	.41	0.39	0.73	0.66	0.12	0.06	0.41	0.39	0.76	0.65	0.14	0.06	2.02	1.69	1.93	[illegible]	0.16	0.08
DISPLACEMENT	2	2.32	1.78	2.14	1.95	0.10	0.07	2.32	1.78	2.24	1.99	0.13	0.09	4.48	1.50	4.27	1.37	[illegible]	[illegible]
(FEET)	3	3.19	2.42	2.97	2.50	0.14	0.11	3.19	2.42	3.12	2.57	0.19	0.16	5.93	1.61	5.55	1.57	0.20	0.14
LONGITUDINAL	1	.36	0.35	0.63	0.57	0.12	0.07	0.36	0.35	0.65	0.56	0.15	0.06	2.11	1.80	1.97	1.44	0.19	0.11
VELOCITY	2	1.28	1.00	1.44	1.21	0.08	0.05	1.28	1.00	1.51	1.23	0.10	0.06	2.70	1.24	2.67	1.07	0.11	0.06
(FT/SEC)	3	1.75	1.35	2.00	1.49	0.09	0.07	1.75	1.35	2.00	1.52	[illegible]	0.10	3.44	1.26	[illegible]	[illegible]	0.14	0.12
LONGITUDINAL	1	.33	0.31	0.56	0.51	0.13	0.07	0.33	0.31	0.59	0.51	0.16	0.06	2.40	2.08	2.23	[illegible]	0.29	0.12
ACCELERATION	2	.74	0.60	1.02	0.90	0.07	0.04	0.74	0.60	1.05	0.91	0.09	0.04	[illegible]	1.13	1.97	0.99	[illegible]	[illegible]
(FT/SEC²)	3	1.00	[illegible]	[illegible]	0.93	0.05	[illegible]	[illegible]	[illegible]	[illegible]	0.95	[illegible]	[illegible]	[illegible]	[illegible]	2.16	[illegible]	[illegible]	[illegible]

TABLE 24

BOOM TIP MOTIONS FOR CRANE AT FORWARD QUARTER POINT, BOOM LENGTH OF 90 FEET, BOOM ELEVATION ANGLES OF 45, 60, AND 75°, AND $H^{1/3}$ = 5 FEET

C5-S-73A CONTAINER SHIP (LIGHT)
LCM-8 LIGHTER CRAFT (LIGHT)
CRANE AT FORWARD
BOOM LENGTH = 90'

SPECTRA
SIGNIFICANT WAVE HEIGHT = 5 FEET
1. PIERSON MOSKOWITZ
2. BRETSCHNEIDER (ROLL PEAK)
3. BRETSCHNEIDER + SWELL (ROLL PEAK)

MOTIONS PREDICTED	SPECTRA TYPE	BOOM ELEVATION = 75°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 456.39 Y = -41.20 Z = 126.73						BOOM ELEVATION = 60°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 471.73 Y = -34.04 Z = 117.74						BOOM ELEVATION = 45°, SLUE ANGLE = 45°, TIP LOCATION IN SHIP COORDINATE SYSTEM X = 43[illegible] Y = -29.30 Z = 103.44					
		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM		HEAD		QUARTERING		BEAM	
		WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED	WORST	PHASED
VERTICAL DISPLACEMENT (FEET)	1	0.66	0.61	1.35	0.96	2.33	2.21	0.71	0.65	1.42	1.07	2.27	2.16	0.74	0.68	1.45	1.14	2.22	2.12
	2	3.06	2.42	7.84	5.75	7.76	7.09	3.26	2.59	7.36	5.72	6.89	6.25	3.43	2.75	6.93	4.82	6.15	5.55
	3	4.21	3.29	16.03	13.80	16.65	16.29	4.49	3.53	14.47	12.13	14.48	14.13	4.71	3.74	12.15	10.74	12.63	12.28
VERTICAL VELOCITY (FT/SEC)	1	0.59	0.54	1.20	0.83	2.25	2.14	0.62	0.57	1.34	0.96	[illegible]	[illegible]	0.60	[illegible]	1.27	1.02	2.15	2.05
	2	1.72	1.39	4.50	3.19	4.52	4.13	1.83	1.50	4.24	2.93	4.05	3.64	1.92	1.55	4.03	2.74	3.65	3.11
	3	2.34	1.85	8.91	7.60	9.28	9.06	2.49	1.95	8.06	6.76	8.09	7.88	2.62	2.12	7.35	5.95	7.09	6.87
VERTICAL ACCELERATION (FT/SEC^2)	1	0.53	0.49	1.10	0.84	2.27	2.15	0.56	0.52	1.13	0.90	2.21	2.10	0.59	0.55	1.15	0.95	2.17	2.06
	2	1.02	0.86	2.67	1.63	2.81	2.57	1.09	0.92	2.55	1.71	2.56	2.33	1.15	0.98	2.45	1.65	2.35	2.14
	3	1.35	1.09	5.00	4.21	5.27	5.13	1.43	1.17	4.55	3.73	4.63	4.49	1.51	1.24	4.18	3.34	4.08	3.95
TRANSVERSE DISPLACEMENT (FEET)	1	0.00	0.00	1.02	0.63	2.45	2.33	0.00	0.00	0.99	0.58	2.37	2.24	0.00	0.00	0.92	0.51	2.22	2.09
	2	0.00	0.00	16.17	14.41	19.71	17.56	0.00	0.00	15.20	13.41	18.45	16.31	0.00	0.00	13.60	11.75	15.44	14.30
	3	0.00	0.00	39.44	35.78	46.85	41.85	0.00	0.00	36.97	33.50	[illegible]	[illegible]	0.00	0.00	32.96	29.28	36.89	33.90
TRANSVERSE VELOCITY (FT/SEC)	1	0.00	0.00	0.92	0.50	2.39	2.22	0.00	0.00	0.90	0.46	2.31	2.13	0.00	0.00	0.84	0.40	2.18	2.00
	2	0.00	0.00	8.98	8.03	11.02	9.93	0.00	0.00	8.44	7.47	10.37	9.23	0.00	0.00	7.55	6.57	9.20	8.12
	3	0.00	0.00	21.73	19.72	25.84	23.13	0.00	0.00	20.37	18.35	24.15	21.45	0.00	0.00	18.16	16.14	21.46	18.75
TRANSVERSE ACCELERATION (FT/SEC^2)	1	0.00	0.00	0.92	0.44	2.52	2.26	0.00	0.00	0.93	0.40	2.45	2.17	0.00	0.00	0.85	0.35	2.32	2.04
	2	0.00	0.00	5.03	4.59	5.28	5.72	0.00	0.00	4.73	1.71	5.09	5.33	0.00	0.00	4.21	3.69	5.26	4.71
	3	0.00	0.00	11.99	10.98	14.31	12.64	0.00	0.00	11.24	10.13	13.38	11.91	0.00	0.00	10.02	8.93	11.83	10.42
LONGITUDINAL DISPLACEMENT (FEET)	1	0.41	0.29	0.75	0.65	0.13	0.06	0.39	0.37	0.70	0.61	0.12	0.05	0.35	0.33	0.62	0.54	0.11	0.05
	2	2.32	[illegible]	2.22	1.97	0.12	0.08	2.21	1.68	2.08	1.86	0.11	0.09	2.04	1.53	1.87	1.67	0.10	0.07
	3	3.19	2.47	3.08	2.55	0.18	0.15	3.04	2.28	2.84	2.40	0.16	0.14	2.79	[illegible]	2.59	[illegible]	0.15	0.12
LONGITUDINAL VELOCITY (FT/SEC)	1	0.36	0.35	0.64	0.56	0.14	0.06	0.34	0.33	0.60	0.52	0.13	0.06	0.30	[illegible]	0.53	0.36	0.11	0.05
	2	1.28	1.02	1.49	[illegible]	[illegible]	0.05	1.22	0.94	1.40	1.14	[illegible]	0.05	1.11	[illegible]	1.25	1.02	0.04	[illegible]
	3	1.75	1.35	2.07	[illegible]	0.12	0.09	1.67	1.27	1.34	1.42	0.11	0.09	1.53	[illegible]	1.34	[illegible]	[illegible]	[illegible]
LONGITUDINAL ACCELERATION (FT/SEC^2)	1	0.33	0.32	0.56	[illegible]	0.15	0.06	0.31	0.29	0.54	0.47	0.14	0.06	0.27	0.26	.46	[illegible]	[illegible]	[illegible]
	2	0.74	0.63	1.05	0.61	0.09	0.04	0.71	0.57	0.95	0.75	0.09	0.04	0.64	[illegible]	[illegible]	0.67	[illegible]	[illegible]
	3	1.09	0.74	[illegible]	0.94	0.07	0.06	0.94	0.73	1.24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 25

SAMPLE COTS DESIGN DATA FOR QUARTERING SEAS, SEA STATE 3 ($H^{1/3}$ = 5 FEET), A BRETSCHNEIDER SPECTRA, A 120-FOOT BOOM AND A 60° BOOM ANGLE AT THE FORWARD QUARTER POINT

MOTION DATA	TIP MOTION BOOM PARALLEL ℄	TIP MOTION BOOM OVER SIDE	RELATIVE MOTION BOOM OVER SIDE
VERTICAL DISPLACEMENT (FT)	5.55	8.51	10.55
VERTICAL VELOCITY (FT/SEC)	3.28	4.85	6.19
VERTICAL ACCELERATION (FT/SEC^2)	2.05	2.84	3.92
IN-PLANE DISPLACEMENT (FT)	2.34	18.06	19.27
IN-PLANE VELOCITY (FT/SEC)	1.58	10.03	10.79
IN-PLANE ACCELERATION (FT/SEC^2)	1.12	5.61	6.19
OUT-OF-PLANE DISPLACEMENT (FT)	18.26	2.47	4.50
OUT-OF-PLANE VELOCITY (FT/SEC)	10.14	1.67	2.82
OUT-OF-PLANE ACCELERATION (FT/SEC^2)	5.68	1.74	1.97

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